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TRANSACTIONS
OF THE
AMERICAN SOCIETY
FOR
STEEL TREATING

VOL. 1 OCTOBER, 1920 No. 1

PHILADELPHIA CONVENTION

Special Features

The Function of Insulation and Its Application to Heat Treating Furnaces.....E. F. Davis
The Application of Pyrometers to the Heat Treatment of Steel.....A. M. Redding
Steel and the Forge Shop Man.....F. L. Moister
Producer Gas for Heat Treating....Geo. H. Trout
Dentritic Steel.....H. G. Carter
A Process for the Manufacture of Helical Springs for Heavy Duty.....T. D. Lynch
Steel for Machine Parts.....R. M. Taylor

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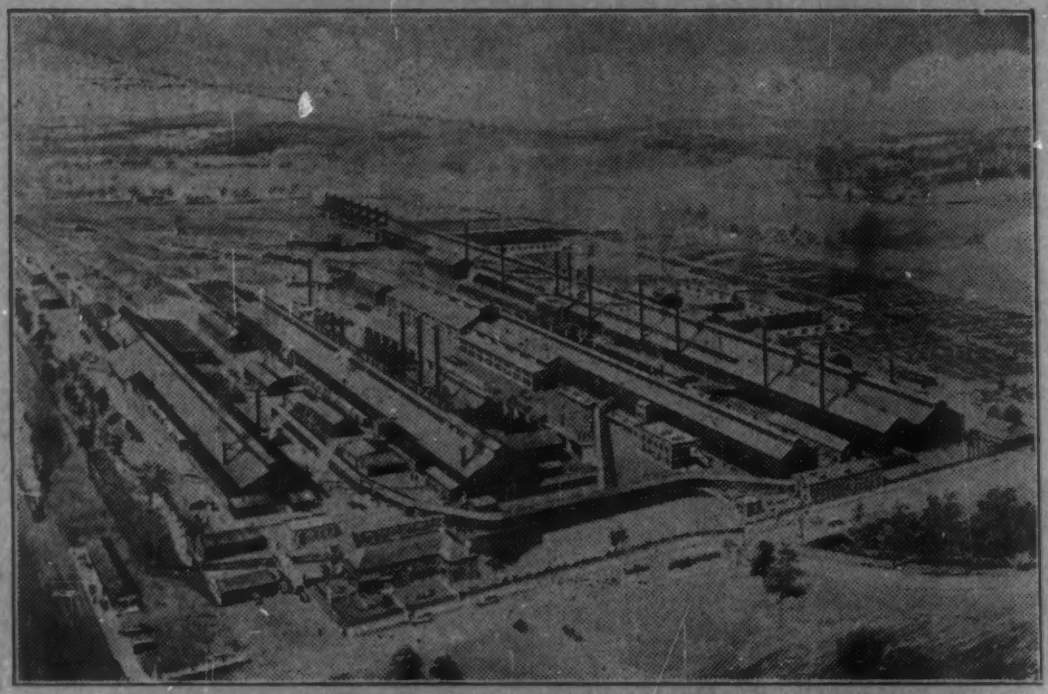

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Year Book of the Society ..... Vol. 1, No. 5, Pages 1 to 91

EDITORIAL

EDITORIAL FOR TRANSACTION OF AMERICAN SOCIETY FOR STEEL TREATING

Greetings are extended to all of the great fraternity interested in steel treating, and especially to those who are members of The American Society for Steel Treating. The society had a most auspicious start at its convention and exhibition in Philadelphia, as all of you who were enabled to be at the meetings know. The booths were well arranged and very well patronized. The meetings were especially well attended and the papers heard with much interest.

It is hoped that the membership committees in our various chapters will be especially active these next few months in building up the membership. This suggestion is made not from the angle of seeking increased membership, but because it is believed the society has a message to extend to all the many thousands interested in heat treatment, and an increased membership is a most effective means for transmitting this message. It is suggested that an attempt be made to make the membership well rounded. Interest in the society should be created from among heat treatment shop foremen, plant superintendents, laboratory technicians, etc. No one is in too humble a position, nor no one in too high a post, provided there is the basic desire or need for information in this field, to debar him from membership in the society. It will only be with a well rounded membership that the society can grow. The creation of interest from all classes in this one field will be of great value to the individuals, will insure live meetings, and will be of broad benefit to the profession as a whole.

A. E. WHITE, President.

The 1920 convention and exhibition of the American Society for Steel Treating is now a memory. But such a remembrance! The magnitude of the exhibition, the success of the meetings, the remarkable quality of the papers presented, the large and enthusiastic attendance, all these and many more important incidents and events combine to reflect credit upon the young and rapidly growing society.

May the efforts of the members continue in the channel of progress and thus may each convention and exhibition set an increased standard of excellency, a higher goal towards which to aim and strive.

THE CONVENTION

Opening Session of the Second Annual Convention of the American Society for Steel Treating was called to order at the Commercial Museum, Philadelphia, Pa., September 14, at 10 a. m., by Chairman A. E. White of the Amalgamation Committee.

CHAIRMAN: I know that it is with great pleasure that all of us are able to be here in this room this morning, at what is substantially the Second Annual Meeting of these Steel Treating Societies, which, in but a few moments, will become one society.

We are indeed fortunate this morning in having with us the direct representative of Mayor Moore of Philadelphia, who tells me that he has represented seven Mayors of Philadelphia. I wish you could have all heard the wonderfully complimentary remarks made with regard to him by a real Philadelphian when he told me that Dr. Cottrell has spoken to

over two million people, he has heard him six times on substantially the same subject, and could hear him six times more and at each time with greater interest It is with great pleasure indeed that we are able to turn this meeting over for a few moments to Dr. Cottrell, who will represent the City of Philadelphia and formally welcome this society to this city.

DR. COTTRELL: Mr. President, Officers of the Association—Gentlemen: I am very happy to be here, although I do regret that His Honor Mayor Moore, being out of town, is unable to give in person the official welcome of the City of Philadelphia. He is very much disappointed, and he asked me to convey to you that sentiment. You have the keys to the City, and we beg to say you are doubly welcome. We are very happy to have you here and very proud to have you meet here in Philadelphia. I am very happy, out of this misfortune, to have this opportunity to look into your faces and bid you God speed. It has been my privilege to be associated with seven of our Mayors, taking in nearly a quarter of a century, and to have been associated with the building up of this commercial Museum. This was the first movement under President McKinley to develop foreign trade here in 1893. They have the records here of over 350 thousand foreign firms all over the world. In this very building we held in 1899 the Congress of Commerce, with delegates from every country in the world. It cost the city about $150,000 to take care of that convention, but it was the mother or the beginning of that great foreign trade which I feel is the hope of the whole world, and on nothing else is that trade so dependent, in my mind, as upon the steel industry. You are the kings of the future. I find in fifty years of clear-cut memories—I have known every President since Abraham Lincoln—I have written about 85 separate organized governments, spending about 25 years in travel all over the world, studying our own government and contrasting it with other governments—last year it was my privilege to look into the faces of 1,100 different audiences—I believe my total in the last 17 years runs up to seventeen million people. I mention those facts to give force to my words that I have at this moment a stronger faith in our form of government than I ever had at any other period in my life, and I am more optimistic about the future than I ever was at any other period of my life. (Applause.)

Some 500 or 600 of those meetings last year were meetings where organized labor was prominent, and I said in New London recently, speaking to the New England Bankers from all over New England—and I said again in Buffalo and in Cleveland, that from my knowledge of labor I believe 97 per cent of the labor of America was bomb-proof against Bolshevism, because the home life is the basis of our real life, and Bolshevism is founded on the principle and determination to destroy the home.

As for trained leaders, you take the work of our universities and take the work of our great shops and wherever I go I find a more indulgent direction and a heartier cooperation between the individual workers and the leaders.

I was so struck recently by a trade publication account of one of our big manufacturing establishments here and the get-together spirit they showed that I sat down and wrote them a letter from the Mayor's office, congratulating them and saying how it put new heart into me in going about the country and trying to say some good words about Philadelphia. They printed my letter in full, photographed in their house paper. I talked to two thousand foremen not long ago, and I was struck with the

wonderful level of intelligence that was everywhere shown in looking over that sea of faces, and the family spirit, the cooperative spirit that seemed to be developed.

Let's take our courage in both hands and regard this meeting that gives you a chance to prove that "sovereign and Divine right" is not a grace alone; that in this crisis of the world, when the whole world is leaning on America, that each one of us has responsibilities we must live up to, and that, living up to them, there is no doubt about what the result will be in our ability to help America lead the world back to paths of pleasure and peace.

It is delightful to come out in the early morning and face a body of men like this—so different than the question which the little boy asked of his mother, "Mother, where does the light go when it goes out?" And she replied, "That is a foolish question, you might just as well ask me where your father goes." You are all alike; you are men, and know life and enjoy it. Thank God for life. That is the prayer of my life. I have lived a good many years. I have had a good deal of fun. I have known both ends of the string. I have lived on $500 a year and spent $25,000, and I have been equally happy in both conditions. I have been all over the world; I have been thousands of miles from here where I didn't know anybody, and I have been where I had friends all around me—we have that touch of Divinity that if we will only feel it gives us power to stand squarely on our feet. If we get a blow, go to the grass, wipe the blood off and get into the race again and fight and win. "He who wrestles with me strengthens."

Now a good many of us have had to take that kick in the face before we learned a lesson. I believe that by organization, by consolidation of organizations, you are getting into a position where you are able to avoid that kick, and learn in a pleasanter way the great lessons of life we have all got to learn if we are going to live and let the other people live. Don't be afraid of getting old. I want to live to be 100 years old, and then renew the lease and double the rent and do my own repairing, and keep the furniture—you never see cheap furniture with a marble top. (Laughter.) You can always get a bright slant if you want it. Even the prohibition act has a silver lining; when your wife kisses you when you come home now it is a kiss of affection, not of investigation. Try to find the bright side. Pessimism and paralysis are synonyms. A pessimist is a blind man in a dark room looking for a black cat that is not there; a fellow who don't amount to anything and would lick his child for growing. Take the other slant of it. Be like a little chap that fell down stairs in one of our public buildings and when I picked him up he said, "That's all right, Mister, I was coming down anyway."

I am very glad to welcome you on behalf of the Chief Magistrate of Philadelphia, the 109th of this City. We were founded in 1683 so we have a long list of over 225 years back of us. We began with certain principles laid down by William Penn which the whole world is adopting today. If you will take the latest Bankruptcy Act, if you will take the latest act on foods and drugs, those acts which endorsed honesty and fair dealing, I will show you sentence after sentence that is verbatim from letters written by William Penn—"Irrespective of the ability or disability to judge measurement the exact quality and quantity bargained for must be delivered." All provisions in those early days were made to prevent debtors escaping. There are a thousand and one things in the original plans for the City of Philadelphia, for the City Beautiful, that are being

carried out today in other cities all over this country. We were to have trees on every street and trees between every house. There was to be an orchard attached to each home so the children could see nature in her productive mood. All these modern improvements were born in that old day, because Penn was a courtier before he was a Quaker. He was associated with all the brilliant men of the Continent in his day and when he came over here he laid down just one rule—that was that a man must believe in a God, but after that it was left free. He couldn't understand the brotherhood of man unless you have the Fatherhood of God. So we started with the idea that thrift also was a virtue, and, beginning early in Pennsylvania, we have been able to pass on to each generation enough capital to handle their new development so we stand today with fewer outside debts I believe than any other community in the world. It is only within about four years that we began issuing our first bonds in the State of Pennsylvania, and they are to build roads. Our debt here doesn't represent more than one-half the value of our assets in Philadelphia, because we have been limited under the Constitution for years, until two years ago, to making a loan which must be paid in thirty years. We have tried to develop the home life here because we believe that home life is the basis of all happiness and contentment; because we believe in the home you can teach a lesson that cannot be taught anywhere else; because in the home the child obeys a law, not because it understands the law, but because it has love for, and confidence in, the law-giver. The trouble today is that every man wants to interpret a law according to his way and his views, and there is a very widespread tendency to break a law we don't like, and obey a law we do. I heard some men at the club boasting about how they were getting about the Anti-liquor law. They didn't like it. I said to one of those men, "I take no position on that question—I have used the spirits for many years, but don't forget this: You have property that is protected by law. You have a splendid auto protected by law; here is a man who don't believe you ought to have an automobile; he don't like the law that lets you wear a diamond pin and carry a watch or carry money in your pocket, and he breaks that law and takes your watch and assaults you and takes your automobile; you don't like the Prohibition law, and you break it. You each occupy in law exactly the same position, and if our government is to continue—because it rests on the law-abiding spirit—any man who breaks any law is giving license to another man to break any other law; that is the principle we have got to consider, because under our form of government it is voluntary law-abiding from within rather than compulsion to obey a law from without." Last night we guarded in this city 435,000 buildings scattered along 1,750 miles of streets, with 1,000 men, because nine out of every ten men are law-abiding, and law-respecting in America. Had we been under an autocratic government such as the old Russian Government, it would have taken 25,000 men to enforce obedience to law, where the 1,000 men was sufficient here. Now under our form of government the difference between the expense of 25,000 law enforcers and 1,000 gives us a fund out of which we spend two and one-half million dollars a day for education, and two and one-half million in supporting the great moral agencies. Every time the man obeys the law voluntarily he relieves the state of a certain amount of expense and leaves a larger sum to build the things that build character and so buttress the foundations of our great Republic. We have in the City today 390,000 separate dwellings. You will notice the tracks with the

trolley car going by. That is one of a family that today will go ten times around the earth without going out of Philadelphia. The total mileage of all the cars in Philadelphia will run about 240,000. If you wanted to make a call at each of our homes, it would take you twelve years. You could go through our water pipes from here to St. Paul and down to Omaha. In normal times when we are running on our usual schedule, occupying our 350,000 army of skilled labor, we turn out every second 25 pairs of stockings; every second we make a new saw; every two seconds we make a new hat; every three seconds we make a new pair of lace curtains; we build a trolley every hour, a locomotive every two hours. In normal times we build a new home every twenty minutes and a new baby every thirteen. (Laughter.)

And in that connection I once heard of a strange thing that happened. I was down in North Carolina, and I said to one of the men there, "You have a remarkable increase in births here, how did it happen?" "Well," he said, "the Southern Railroad put on a new train that went through here at 4:00 o'clock in the morning and woke everybody up." (Laughter.)

Along that line, my dear old father helped to bring Texas into the Union, and to take it away from Mexico. About 25 years before he died he went down to revisit some of the old towns he knew and about a few years before he died I revisited the same towns. In talking with the old hotel proprietor I said, "My friend, how many people have you now?" "About 4,800," he said. "You mean 48,000, don't you?" I asked him. "When we were here twenty years ago you had that many, and the nation has grown nearly forty million." "Well," he said, "that was exactly the count according to the census that was taken not long ago." I said, "That is strange; have you any theory? Has the birth rate kept up?" "Yes," he said, "the birth rate has kept up all right, I guess; about the only way I can account for it is that every time a baby is born some fellow has to leave town." (Laughter.)

You see they broke even. And there are a great many people in the business and other lines that are doing a tremendous business at the front door and losing it at the back, either through lack of education and intelligence or through lack of the moral qualities. We have to be sure that we both understand the word "straight" to mean the same thing. Out in Cleveland not long ago they arrested a Darkey for selling stewed rabbit adulterated with horse meat. They asked him how he adulterated it and he said, "Well, I did it on the 50-50 basis, one horse to one rabbit." (Laughter.) Don't let's jump at the idea that the other fellow believes as we do. I want to welcome you on behalf of the City Chamber of Commerce, also. We have, I believe, the largest membership in that body of any similar body in America, over eight thousand now. All the great agencies are working together to make the old mother city renew her youth and be able to live up to the traditions of the past. I bid you welcome in their name as well as the name of the city. I ask you to forget the technical side of your meeting while you are here, get out of the rut that we all get into for a little while, get a little to yourself and go down for just a little while to that old Independence Hall and stand for a few momens and listen to the message which that old bell will give to you, individually. I have now nearly 59 years of memories of that bell. An early memory was the day when Lincoln lifted the flag in '61. He was little honored then; didn't even have a guard; he was going down to Washington to be inaugurated.

Then I remember in '65 being in the room after standing all night in

Independence Square, after God had called Lincoln home, and in the early dawn going into the old room that the Declaration was signed in and looking at the face which seemed already to my eye to hold the light of Eternal morning. I was there two years ago with a college professor and he sat on the rostrum where the Presiding Officer at the Constitutional Convention sat years ago, and that college professor today is the President of a mighty institution.

In the same building I attended three or four great conferences, and out of those conferences have grown Independent nations that exist today. The old mother city in that old cradle which rocked our new nation into being has rocked other nations, and we are the foster mother.

But one memory I have that I hope God will let me have to the last, and that is when I took a young sailor there one night during the war. I had been down there to see that the bell was tolled at 9 in the evening. We were having certain general observances here, and as I came back an officer was having a dispute with a big sailor, a fellow about 24 years old, standing about six feet two. I went up to see what was the trouble and the officer said, "Dr. Cottrell, this boy wants to go in to see the Liberty Bell, and I told him that the place is closed, but he won't take my word for it and wants to go anyway; you tell him that he can't see the bell tonight." I said, "My dear fellow, the officer is telling the truth; come down in the morning and I will be delighted to take you in. You are answering the call of that bell." He said, "I can't do it; I have just gotten into Philadelphia at 6:00 o'clock tonight; I have never been in Philadelphia before, but my mother was born in Philadelphia; all her life we lived in Milwaukee, and all her life she used to talk about that Bell and her Bible. Last February God took father from me, and my mother and myself have been more like brother and sister since then. Then the mother went away, and I was left alone. I went into the Navy because I thought I would be nearer the mother fighting, but I would like to see that bell; it would bring her back I think for a moment and give me a new grip." I said, "My boy, you are going to see that Bell." I took him around to the Wall Street side and knocked on the door. The watchman was just finishing his hourly inspection of the tower. I said to him, "You know I represent the Mayor and I am going to take authority here for a moment; I won't violate any of your provisions; enough light comes from the lamp post in the square by the Barry Statue." I led the man into the vestibule. The Bell was then nearer the door than it is today. It was very dark in there, but I could see the bell and I put his hand on it. Then I stepped into the shadow, thinking I could open the window so it would let in a little light. When I turned to come back—of course I was concealed in the shadow—and I was sorry for a moment I was there, because the boy, thinking himself alone, had dropped on his knees in front of the bell, and as I watched him with his face silhouetted with the light from the square I saw his face lower until his lips touched the Bell. Then I heard him say, alone in the darkness, "God help me to make good." That big boy was nearer the mother he had loved and lost at that moment than he will ever be again until he meets her. That is the spirit that our boys had, all of them. That was the spirit which animated the seventy thousand Americans who sleep today over seas, and every one of those seventy thousand Americans that are sleeping over there signed a bond with his life blood which you and I have got to sign and keep to be bigger and better Americans in the days that are to come than we have ever

been in the past. We have got to make Old Glory mean more. We have just listened to. It would be a case of anti-climax, and it would be recognize that the world don't owe me a living; I owe the world a life; by playing the game straight as well as strong, recognizing that we are "sovereigns of Divine Right," touched with the Quickening Finger of the Living God; we have got to carry this country through any crisis and to make America the hope of the whole world.

May God bless your deliberations, make you better citizens, make you more able to hold Old Glory aloft where it ought to be the hope of mankind. (Prolonged Applause.)

CHAIRMAN: I am sure that we feel we owe the City of Philadelphia a debt for sending to us Dr. Cottrell to welcome us officially to this glorious old city. We all know of Philadelphia as the "City of Brotherly Love," and I think all of us in this society feel exceptionally fortunate in being able to come here and hold our annual convention and our annual exhibition. It would not be fitting for me to attempt to make any response at this time to such a splendid address and such a wonderful tribute as we have just listened to. It would be a case of anti-climax, and it would be better not to say anything than to have a condition like that.

I think, however, that it is exceptionally fortunate that we are here. I couldn't help feeling last night just before I went to sleep how fitting it was that we assemble here in Philadelphia. Philadelphia, as we know, was the city in which our forefathers gathered and prepared the Declaration of Independence. It was not the first time that the Continental Congress met, but it was the first time that Continental Congress welded hands together so that this nation might rise and become the power for good and the uplifting of humanity that it is today, so I hope that at this time, although it is not the first time that either one of the societies that are becoming amalgamated have met, yet it is the first time that they are meeting in a spirit of union, and as the Declaration of Independence rang out that spirit of Liberty and power and strength, so I hope that at this convention it will be the start of what is already a vigorous and strong society, but which we hope from now on will become bigger and stronger and better and more resultant of the things for which our society stands.

Again I wish to thank Dr. Cottrell, representing the City of Philadelphia, for being with us this morning.

DR. COTTRELL: I am very happy indeed to have been with you, gentlemen.

CHAIRMAN: Our next order of business is the appointment of the tellers, and in that connection I appoint Mr. Collins of the Philadelphia Chapter, Mr. McCloud of the Detroit Chapter, and Mr. Smith of our Indianapolis Chapter.

CHAIRMAN: I think it is highly appropriate at this time just preceding by a few minutes the formal announcement of the amalgamation of the two societies, that we have an Annual Report from the Presidents of Both Societies, and I will therefore at this time ask Professor John F. Keller, President of the Steel Treating Research Society, for the report of the Steel Treating Research Society. (Applause.)

PROF. KELLER: Gentlemen, fellow members of the Steel Treating Research Society, members of the American Steel Treaters' Society—I am glad to be with you today. This report, however, has been prepared for the members of the Steel Treating Research Society. There are some few notes on the American Steel Treaters' Society.

REPORT OF JOHN F. KELLER, PRESIDENT STEEL TREATING RESEARCH SOCIETY

It affords me great pleasure indeed, to present to you, a final report of the splendid progress and activities of this, the first scoiety of its kind organized in this country. The object of which was to furnish information to the practical Heat-Treater, through the presentation of papers and discussions of the various phases of their work—eventually to bring about a closer relationship, between the graduate Metallurgist and the practical Heat-treater, hoping thereby to combine theory with the practical knowledge of men; who, in many cases devoted the greatest portion of their lives to the manipulation of Iron and Steel.

It was to the vision and foresight of a practical Heat-treater that we are everlastingly indebted for the foundation of this splendid gathering here today.

It was to this man, who had risen from the trade of a Blacksmith and practical Heat-treater, to that of a service man for a large Steel Producing Company, whose duty it was to furnish information and demonstrate proper methods of treating Steel to Foremen of such departments.

In his daily vocation, he soon discovered the limitation of the average workman and their willingness to accept advice. From this, he conceived the idea of bringing together a number of men interested in their work. The first gathering from which this Society grew met in the year 1913, at the Fellow Craft Club, and consisted of eighteen Heat-treating Foremen. The meeting was so successful from a social and educational point of view that after a few such meetings, it was suggested that a Steel Treating Society be formed and that the gathering be held regularly each month. This was unanimously adopted and the Society was formed. Mr. Lawson of the Cadillac Motor Company was elected as the first President for the year 1914.

The growth and expansion from this humble gathering of practical Steel Treaters is past history, but great credit must be given to the man who conceived and assisted in building the foundation of this great Society. The gentleman is none other than our esteemed fellow co-worker and past President of the Steel Treating Research Society, Mr. W. P. Woodside, a man who is deserving of the sincere thanks and appreciation of every member of this Society, and in fact from all future members, for his unselfish efforts in promoting an organization of educational value to practical Heat-treaters, and which made possible the Society of today.

In reporting the splendid progress of our Society during the past year, I feel that you are entitled to an apology for my apparent indifference to the active official business of the Society; but I wish to assure you that although business required very close application nearly all of my time, this very fact enabled me to further the progress and interest of the Society through close personal contact with industrial employes over a widespread section of the country. Also as regards my not maintaining actual control of the business of the Society in my absence, it was being taken care of by our very accommodating and enthusiastic Vice-President, Mr. L. A. Danse, and efficient Secretary-Treasurer, Mr. L. S. Carrick, for which valuable assistance I sincerely thank them.

My greatest desire and ambition, however, was to bring about a more cordial relationship between the officers and members of the two great Steel Treating Societies. With this in view as the main objective, I decided to put forth every possible effort to create a more fraternal

feeling between the opposing factions, and if possible, to assist in uniting the entire membership of both Societies into one harmonious organization.

In my humble efforts to bring about this desirable condition of affairs, I am very glad to report that I found a fertile field indeed, for action. The universal opinion among the majority of the members of both Societies was for a consolidation on the popular grounds that there was not room for two Societies functioning along the same line of endeavor. With this general feeling and desire as an excellent foundation to work upon, the next step was to approach the representative of the other Society with that fraternal feeling of, "Brother, I will meet you half way for the good of the greatest number." I am pleased to report that the fraternal feeling was reciprocated in spirit as well as in action. The splendid co-operation of the national officers of both Societies in this matter is a series of interesting and profitable meetings that I shall always remember with pleasure. The commendable, loyal and untiring effort of the various committees appointed deserve exceptional praise for the laborious tasks so well performed.

With this combination of unselfish efforts and good will of all concerned, the culmination of our desire and ambition was gloriously achieved when the voting power of the national officers and members decided by unanimous vote to amalgamate under the banner of the American Society for Steel Treating.

In the achievement of our objective and desire for the above amalgamation there is one man who must be given entire credit for its success. It was through his untiring and unselfish efforts as a neutral that the first meeting was arranged at Battle Creek, Michigan, September 2, 1919, at which meeting a committee was appointed to prepare a tentative constitution and plan of action for approval and recommendation of the officers of both Societies. From his concentrated efforts at this meeting and all others the superstructure of the American Society for Steel Treating was outlined, constructed and cemented together. The finishing touches to his ideal structure created for the benefit of the Steel Treaters of the country will be completed when the first convention of the American Society for Steel Treating is called to order this week. The foundation of his ideal, however, has only begun, for he anticipates making the American Society for Steel Treating one of the most successful and useful organizations of its kind to the manufacturers and users of Steel in the country, if not in the world. Gentlemen, I refer to Professor A. E. White, National President of our new Society. I assure you he is deserving of the heartfelt thanks of every officer and member for his unselfish efforts and his loyal devotion for the good of all concerned.

There is one other gentleman that deserves our thanks and appreciation for the culmination of efforts toward the amalgamation of our Societies. I refer to Mr. T. E. Barker, President, American Steel Treaters Society. In all my consultations and associations with Mr. Barker in committee work and otherwise I found him a perfect gentleman, a conscientious official, extremely loyal to his organization, but always willing to concede a point where it would do the most good for the greatest number, and a man who is deeply interested in the personal and educational welfare of the Steel Treaters of the country. I take this method of thanking Mr. Barker for his courteous treatment and his untiring efforts toward the complete and successful amalgamation of the two Societies. I also wish to congratulate the Nominating Committee for selecting Mr. Barker as Vice-President of our new organization.

This part of the report would not be complete without expressing our appreciation and thanks to the members of the Amalgamation Committee for their prompt attention to the strenuous task of developing the remarkable constitution submitted for ratification.

Personally, I have been unable to take a very prominent part in the various activities of our Society or the amalgamation proceedings. However, I have visited the following Sections, Chapters and Societies for the purpose in most cases of delivering a talk and demonstration on "Steel, Its Selection and Treatment," as follows:

The Fellow-Craft Club, of Flint, Michigan, our Indianapolis Section, The Cincinnati Chapter of the American Steel Treaters Society, an open meeting of the Steel Treaters of Toledo, Ohio, which was finally organized as a section of our Society; the organization meeting of the South Bend Section, the Rockford Engineering Society, of Rockford, Illino... and the Chicago Chapter of American Steel Treaters.

In conclusion, gentlemen, I want to personally thank all of the members for the splendid cooperation that has been given me in my work. I also want to thank our members for the splendid effort and their splendid cooperation towards the successful amalgamation of this society. You have the combined membership of both societies represented among the new officers, and you have selected excellent officers, men who, from my personal experience, association, and working with, I believe will develop a society of considerable strength. They will lay down laws which have already been laid down; they will make an effort to develop this society, but I say to you members, these men cannot do much in their efforts unless they have the combined cooperation of each and every member of the organization.

CHAIRMAN: At this time I want to call the attention of all here to the very excellent program of papers which the program committee have been able to secure. It was my good fortune yesterday afternoon to be able to casually look them over, and I was surprised and pleased to note the excellent character of every one of the papers. Our Program Committee is to be congratulated in getting the papers and in the care with which they have been selected. I feel that none of you men can afford to miss the papers which are presented here.

It is with great pleasure that at this time we can call upon Mr. T. E. Barker, the President of the American Steel Treater's Society, for his Annual Report.

PRESIDENT BARKER: Mr. Chairman, Officers, Delegates and Members of the American Steel Treaters Society and the Steel Treating Research Society; it is true, as our Chairman says, that my name is Barker, but I want you to know that I am very sensitive about being mistaken for one of the Mexican Hairless variety. I might elucidate upon that a little by relating a little story that I ran onto a few days ago. I don't recall just what it was, possibly the Ladies' Home Journal, but O'Brien's over-educated daughters were endeavoring to bring up father, who had made a large fortune as an excavating contractor, by inveighling him into refined society at every opportunity. So they got daddy into the family automobile one evening and motored him over to Mrs. Smith's to a meeting of a literary circle. Upon being introduced to the hostess she exclaimed, "Oh, Mr. O'Bri'n, I am so delighted to meet you; I have heard so much about you. I understand you are a very well read man."

"You do, do you?" said OBrien. "Yes—Mr. O'Bri'n, have you read Spencer's 'Synthetic Philosophy'?" "I have not," said O'Brien. "But you have read 'The Four Horsemen of the Apocalypse'?" "I have not." "Surely you have read 'The Trail of the Lonesome Pine.'" "I have not." "Well, Mr. O'Bri'n, will you tell me, please, what have you read?" "Sure, I have red hair on me chist." (Laughter.)

Now I am going to try to be a little more serious, although I feel so good over this affair that it is questionable whether I shall succeed or not.

Professor Keller has gone over the early history of the Steel Treating Research Society and the events which have led up to the amalgamation, and I shall not dwell much upon that point. What he says of the Research Society is essentially true of the growth and development of our society. The Good Book records that God, shortly after he made man decided that it was not good for him to live alone, so he plucked from Adam a rib and from it made Eve. It seems that God has exercised the same wisdom in the creating of the Steel Treating family, and now that these two societies are to be joined, united, it is my happy privilege to give away the blushing bride, the Eve, made from the first rib of the first steel treating society. And it is with a great deal of pride that I present this buxom young amazon, glowing with health and strength.

It is the usual custom in ceremonies of this nature for the bride to assume the name of the groom, but in this case they have, both societies, both parties to the contract, agreed to adopt a new name, or rather a combination of the old names, sort of splitting the difference as it were. You know the original Adam and Eve split the difference and raised Cain. They did it again when they got Abel. (Laughter.) But I trust that no cain will be raised because of this union. On the contrary I hope and predict that this union will result in everlasting harmony, and in success in all those things for which we are organized.

There is just one phrase in Professor Keller's report that I don't believe he really meant. He spoke of the two societies as opposing societies. I don't believe they were opposing. They were simply competing, and it is a good thing to have competition for a time, but that time is past, and it is now time to concentrate our effort and eliminate the duplication.

My report upon the development and growth of the American Steel Treaters' Society is going to be very brief, because I know that you all came here principally to get the real meat of this convention, the papers, the latest developments in the heat treatment processes. Since our last convention, which was also our first convention, the number of our chapters has increased from 9 to 20, or an increase of 122 per cent. Our membership, taken from the books of the National Office, of members in good standing, which, of course, does not include some of the later admissions into the various chapters, was, at last report, 1,700—a little more than that, or a growth of over 270 per cent in the past year.

The very kind words that Professor Keller, President of the Research Society, has said of me are equally true of him. Since our very first meeting we have been hand in hand in this effort to bring together the two societies in a manner which would result in their ultimate greatest strength, which would result in the greatest benefit to the greatest number of men who are interested in steel treating work, either directly or indirectly. At every turn he has shown a disposition to give and take, and a real cooperative spirit.

Professor White should have the credit for the inauguration of this

movement. He took the initiative and he has worked faithfully and very conscientiously and successfully in this work. Few of you know of the enormous amount of time that he has devoted to this work, and it is highly fitting that we should honor him with the highest office which we have to give for the great interest which he has taken, and the success which he has achieved.

Appreciation of the efforts and good work of our officers, committeemen and members was expressed in the last issue of the Journal, September, and I shall not go into all the details now. I presume you have read it, but I do say that I wish I might more clearly express my feelings toward the men who have contributed so much to the advancement of our society, and to the art of steel treating in general. Those feeble words don't half express it. Usually when I have taken the floor before the members of our society, it has been to draw a picture of the future or to set up a target to shoot at, but today that part of the program rightfully belongs to our Chairman, Colonel White, who undoubtedly will be elected our President for the coming year, and I dare say that he will set us a lively pace.

There is one thought that I would like to add to the words of appreciation of those who participated in the offices and hard work of our society which was not expressed in the Journal. I want to repeat a quotation which I first heard from our good friend and worker Bill Bidle, of Cleveland, namely, "He climbs highest who helps another up." The good work done by these committeemen and officers certainly entitles them to climb high, and they undoubtedly will—sooner or later the result of such work will be manifested.

In giving my benediction on this happy pair of steel treating societies I want to relate an old story. This story is so old that you older heads have forgotten it and the younger ones weren't old enough to hear it when it went out of circulation. It is an incident occurring in Chicago a great many years ago—27 years ago to be exact. At that time the city of Chicago didn't have the nice, clean intelligent city government that it now has. Bill Thompson was an unknown quantity. It was at the close of the World's Fair when a proposal was made to the city government and to the aldermen and at that time the aldermen of Chicago were principally saloonkeepers, and incidentally I might say most all saloonkeepers were sons of aldermen. This proposal came to the council that the city should buy the fleet of gondolas that had been plying the lagoons of the World's Fair grounds. A considerable discussion was had, and some dissention arose over the amount of money involved in the purchase of the outfit, when one of them, more thrifty than the others, arose and said, "Mr. Mayor and Gentlemen: What is the use of buying up a whole flock of gondolas? Why not buy just one pair of them and let Nature take its course?" We now have here two perfectly healthy steel treating societies and I say by all means let Nature take its course, and may the resultant family be numerous, strong and wide-spread. (Applause.)

CHAIRMAN: It is with great pleasure that at this time I will ask Mr. L. S. Carrick, Treasurer of the Steel Treating Research Society, to make a report of the financial condition of that society. (Applause.) Mr. Carrick presented his report.

CHAIRMAN: It is with great pleasure at this time that I will ask Mr. Boissoneau, Treasurer of the American Steel Treaters' Society, to make his annual Treasurer's Report.

Mr. Boissonëau presented his report.

CHAIRMAN WHITE: The next on our program, as you will note, is the report of the Amalgamation Committee. As Chairman of the Amalgamation Committee it is with great pleasure that I am able to submit to you the following report. I have the report in front of me. It is somewhat bulky, as you possibly noticed, because we have attempted to keep in this report all of the official communications which have gone forth with respect to the Amalgamation. I know that you are all waiting with interest the technical paper which is to come in just a few minutes, and therefore, with your sanction and with your approval I will not attempt to read this report in any except a very general way.

. . . . Mr. White reads a general report, after which he joins the hands of Professor Keller, President of the Steel Treaters' Research Society, and Mr. T. C. Barker, President of the American Steel Treaters' Society as a symbol of the completion of the Amalgamation of the two societies into the American Society for Steel Treating.

MR. CARRICK: I move you that the report of the Amalgamation Committee be accepted and placed on file and the Committee dissolved, with the thanks of our society for their efforts. (Motion carried unanimously.)

REPORT OF COMMITTEE OF TELLERS

Chairman of Committee

There were 764 votes cast as follows:

Lt. Col. A. E. White for President	757
Mr. T. E. Barker, Vice-President for 2 years	755
Mr. T. D. Lynch, Vice-President for 1 year	751
Mr. W. H. Eisenman, Secretary for 2 years	751
Mr. W. S. Bidle, Treasurer for 1 year	764
Mr. H. J. Stagg, Director for 2 years	760
Mr. E. J. Janitzky, Director for 2 years	751
Mr. W. C. Peterson, Director for 1 year	760

CHAIRMAN WHITE: This completes, gentlemen, except for such incidental matters as may from time to time come up, the formal business meeting of the society. It is with great pleasure, therefore, that we are able now to open the meeting with our technical papers, for which I know you are all waiting with so much interest.

PRESIDENT WHITE: Men, it is with a great deal of pleasure this evening that all of us can be here in this room and join in our Second Annual Banquet. We know of no more fitting place for our convention at this particular period in our history than Philadelphia. It goes without saying that this is known as the "City of Brotherly Love." We know that in the early days it was in this city that the beginnings of our great country started. It is true that our Continental Congress met in other places than Philedelphia preceding the Declaration of Independence, but at the same time that big move which made this nation and had its start began here, and in the same respect we feel that at this particular period in our history when we are joining here as amalgamated societies under the name of the American Society for Steel Treating, we feel that it is fitting that we be here at this time.

Before going further it has been suggested that we ask the National Officers to stand, one at a time, so that you may all see them, and know that they are human. The first person we will ask to stand will be our First Vice-President, Mr. T. E. Barker of Chicago; Mr. T. D. Lynch, our Second Vice-President from Pittsburgh; Mr. William H. Eisenman, our

National Secretary, a man without a home; Mr. William S. Bidle, our Treasurer from Cleveland; Mr. Howard J. Stagg, our Director from Syracuse; Mr. Emil J. Janitzky of Chicago; Mr. Walter C. Peterson of Detroit; Mr. Frank P. Fahy, who has been appointed Director after we received, with regret, the resignation from the Board of Directors of Mr. MacFarland—Mr. Fahy of New York.

All remain standing, amid applause from members.

I assure you, men, it is with great pleasure that I am able at this time to turn the meeting over to our worthy Toastmaster, Mr. Joseph A. Steinmetz, who is President of the Aero Club of Pennsylvania, past President of the Engineers' Club, and in addition member of several Technical and Engineering societies. Major Steinmetz' forebears came over with William Penn on the good ship Welcome, so that it seems fitting that he should speak for the Philadelphia groups in extending welcome to the Steel Treaters of America. (Applause.)

THANKS!

At a meeting of the Board of Directors of the Society resolutions of thanks and appreciation were adopted for all those whose efforts had so materially contributed to the success of the week. The Convention Committees follow:

Convention Committees

Program and Papers—Arthur W. F. Green, Chairman; Walter M. Mitchell, George Howarth, L. W. Fawcett.

Exhibition—H. H. Clark, Chairman; E. J. Janitzky, A. F. Braid, J. C. Clark, D. K. Bullens.

Entertainment—F. A. Hall, Chairman; J. J. Crowe, D. K. Bullens, A. J. Collins, G. F. Pressell.

Plant Visitation—W. M. Mitchell, Chairman; E. G. Hall, William Knowles.

Ladies Entertainment—Mrs. Denison K. Bullens, Chairman; Mrs. Guy Passmore Bible, Mrs. Arthur W. F. Green, Mrs. Frank A. Hall, Mrs. George Kellar, Mrs. E. H. Barker.

PRESIDENTIAL ADDRESS BEFORE THE AMERICAN SOCIETY FOR STEEL TREATING

Lt. Col. A. E. White

It is with sincere feeling that I thank all of the members of the American Society for Steel Treating for the honor and trust they have conferred on me in electing me President of this Society. The heat treatment of iron and steel is a subject in which I have always been interested and it will be a great privilege for me to serve the Society and each of the members as its President.

The formal announcement of the amalgamation of the American Steel Treaters' Society and the Steel Treating Research Society into the American Society for Steel Treating was made this morning. Time does not need to be taken to go into that matter further; but in passing it is with much pleasure that I can look back upon the splendid co-operation given by the members of the Amalgamation Committee and the officers and members in both societies so that the amalgamation might become effective.

It is not fitting that I survey the work of the two societies during the past year. This survey has been splendidly presented by the officers of the two societies, respectively, namely, Mr. T. E. Barker, as President of the American Steel Treaters' Society, Mr. A. F. Boissoneau, as Treasurer of the American Steel Treaters' Society; Mr. John F. Keller, as President of the Steel Treating Research Society, and Mr. L. S. Carrick, as Treasurer of the Steel Treating Research Society. The splendid work which has been done by each of these two societies has been well portrayed and I only hope and I know that in doing so I am expressing the thought of each national and local officer and each member in the society that the same excellent program and good work done by each society individually during the past year may be carried on and performed during the coming year by the amalgamated society.

Since I am unable to view the affairs of the society retrospectively I believe it fitting to present at this time some thoughts relative to the scope and purpose of the society. The one large outstanding field for the society is SERVICE. In fact if it is unable to render service to its members and to the profession for which it stands, it has absolutely no place. Yet looking carefully over the hopes and purposes of the society there is no question but that it is rendering service in the fullest possible measure.

It hopes to keep its members informed on the various changes and improvements which take place from time to time in heat treatment. It wishes to bring to their attention through the medium of its "Transactions" and through various local and national meetings those developments in heat treatment which occur and the multitudinous phases of the field which are continually cropping up and which, unless our attention is especially directed toward them, escape our attention until there arises a period when they can be of intimate service and value to us. It hopes that through the medium of local meetings and the live papers and discussions which take place there, as well as through the medium of the "Transactions," that interest will be developed among the members and among those who should be enrolled among the members so that they will be willing not only to receive but also to give of themselves and of their knowledge so that their fellows may benefit and profit. It well behooves each one of us at this time to analyze ourselves closely and ascertain

whether we are sponges or diamonds. If the one we absorb and are shapeless, if the other we give out and give back many fold of that which is entrusted to us. If each one of us will take it upon ourselves to attend the meetings for the purpose of not only receiving benefit but also for the purpose of discussing various phases of the work with which we are familiar we will be surprised with regard to the extent to which interest will be created in the meetings and the benefit which each one of us will receive.

In this connection the qualifications for the various grades of membership are of a type slightly different from those found in most societies. To be a member one does not have to reach a stage in his profession obtainable only after a long apprenticeship and other possible favorable conditions. To be a member one only has to be interested in the work for which the society stands, to be above the adolescent age and interested in the society matters. Such a description makes possible membership in the society from all classes; those who occupy the humbler positions in the heat treatment shop as well as those who have risen to fields of distinction in the profession. There is no question but what we can all learn from those who are under us as well as from those above us and many times we can learn more from those under us than from those over us. The happy mingling of apprenticeship and experience, of the practical and technical, of user and designer should be of great value and assistance in strengthening the society.

It is hoped that this society will be able to be of great service and value to the profession for which it stands. It should bring into close contact the steel maker and the steel treater. It should acquaint the one with the troubles of the other and it should teach each to realize that the one is helpless without the other.

Further service which this society should render is that of bringing about better contact with the superintendents and managers of those plants engaged in heat treatment and the men in the shops. Not so many years ago there was a time when heat treatment was the work of technically ignorant but skilled specialists. It was handed down from father to son and there were many myths connected with it which it was believed must be followed in order to produce satisfactory results. That day has gone by and now there has cropped out a feeling among certain people that all that is necessary for the heat treatment of steel is a fire, a quenching tank, and material with which to work. This state of mind is just as harmful to the profession as that just mentioned and where found immediate steps should be taken to eradicate it.

In this society I see great possibilities for aid to our national growth and prosperity. Sir William Beardmore, in his address in 1916 as President of the British Iron and Steel Institute, called attention to the great disparity between the labor of skilled mechanics in that hour of great need in Great Britain, and that of the women who were brought into the munitions factories to take the places of their fighting brothers, husbands, and fathers in Belgium and Flanders. The disparity is so startling that it cannot fail but make one think regarding it, for the women though untrained, unskilled, and physically weaker than the men more than doubled the production records of these so-called skilled mechanics. Without, however, considering or entering minutely into this matter, is it not possible that there is something wrong in our social organization? Is it not possible that we are in need of something now lacking? Is it

not possible that through the channels of a society such as ours enthusiasm and interest in our work can be developed to a point whereby we will all give of the best that is in us? The humblest in our heat treatment shops can sit side by side with the superintendents and managers of the plants in which the heat treatment is done. They can meet on a common plane, they can discuss while they are there problems in which they are both interested. The one has as much right for discussion as the other and there need be no fear of possible consequences, in an open minded, liberal, and fair discussion. In fact the manager and superintendent should be able to learn what they need and the heat treatment man should be able to get what he needs much easier as the result of the open discussion than would have been possible otherwise. Therefore, it is my personal feeling that this society will be a great leveller in the best sense of that word and in so doing benefit all classes.

What this society can do for its members is possibly no better illustrated than by the experience of one of them associated with the Chicago chapter. Not many months ago he was in the postal service in Chicago. The publication of the American Steel Treaters' Society came to his attention and because he had formerly been in heat treatment work he looked it over and he felt at once as though he should return to the fold from which he had fled. He talked the matter over with several members in the American Steel Treaters' Society. He found a position and is now one of the superintendents of one of the large plants in Chicago. His pay is much better than it was as a clerk in the postal service but more than the pay is the fact that he has at last found himself and is happy and contented in his work.

This society should also be of great value and service through the stimulation which it should give to research work. I realize that there is a feeling on the part of some people that research work is impracticable, valueless, and a waste of time as well as money, but if we would only be sensible and look back upon conditions we would realize that we would not have advanced very far as a people if it had not been for research.

The work of Kelvin and Joule in the fifties when they showed that compressed gas upon issuing from a nozzle would be lowered in temperature, was not indicative at the time of anything of material value and yet today appreciable quantities of our oxygen and nitrogen are obtained from liquid air secured through the employment of the principles ascertained by Kelvin and Joule.

There is, in these days, much talk about the welding of ship plates rather than their riveting and it is not at all improbable but what there will be one or more ships produced this year with all of the joints welded instead of riveted. Yet this operation would not have been possible without the basic research done by Kelvin and Joule, for welding, except that of electric welding, requires oxygen and the oxygen obtained is secured in general in a manner laid down by Kelvin and Joule.

But coming somewhat closer to our own field, Sir Robert Hadfield has observed that by the use of hot tops he has cut down the wastage in steel ingots in his plants from 6.2% to 1.4%. This general procedure, in passing, is being adopted by all of our alloy steel mills. Some of the plain carbon steel plants are also adopting this method although the question of ultimate cost is one which prevents its more extensive use.

Within the past few years we have all witnessed the tremendous developments in alloy steel. Through researches relating to the composition and heat treatment of steel we are producing armor plate today

one quarter of the weight of that produced twenty years ago with superior impact resistance. In the same way we are producing guns today which are capable of resisting a pressure five times greater than they could have resisted twenty years ago. Also the research work on silicon steels has shown it to be more permeable under low magnetic fields than low carbon steels. As a result, silicon steels, for the past nine years, have come into electrical equipment capable of generating something like fourteen million kilowatts with a resultant annual saving of at least ten million dollars.

In view of all the achievements coming from research work, only a few of which have been mentioned, is it not proper, therefore, that this society should back and support such work as fully and as sympathetically as possible? Are we meeting our full duty if we fail to do so?

It is not right nor fitting at this time to state what your officers and directors will do during the coming year. You can rest assured that each one will do his full bit to the very best of his ability in fulfillment of the honor and trust that you have placed in him by his election to office. Yet you must keep firmly in mind the fact that these officers are merely your servants and are in office merely to do your bidding.

It is hoped that everyone who is in the society will feel that this is his society and will do his best to keep its record clean and make it an effective and efficient servant for the mass of membership as a whole. In this particular connection it is hoped that the local chapters will do as much for themselves as possible. The national officers will stand ready to help the local officers in any way possible but they hope that each local section will handle its affairs in the way which will meet with particular success in the district in which the section is located. It is believed that by placing the responsibility of the local section on itself that each member in the section will take more seriously and more deeply his responsibility than he would were the national officers to attempt to direct the affairs of the sections. It is realized that there is often times strength gained from centralized control but this strength is usually developed at the expense of interest and the national officers above all are desirous that each local section maintain and sustain interest in the society.

It falls to the lot of the President to appoint the national committees. You can rest assured that these appointments will be made only after due reference to the directors and the local chapter heads. That it may be possible for the committees appointed to assemble with the least possible inconvenience and with the greatest possible efficiency there will be a tendency to keep the membership of any committee in reasonably adjacent territory.

Of course, the one great spokesman for the society is its "Transactions." Through it the various activities of the society will be made public and the character and nature of the articles contained in it will be more or less an index of the work performed and covered. I know that I am speaking for those in charge of the publication when I say that an attempt will be made to make it accurate, yet simple and filled with live and useful material in the field of heat treatment.

Again I thank you all for the honor you have personally bestowed upon me. There is no honor but what carries with it responsibility and I trust that you will all feel that I am your servant and that whatever I can do or the directors and national officers can do to be of service to you and through you to the national society, will be taken care of to the best of our ability.

PROGRAM FOR AMERICAN SOCIETY FOR STEEL TREATING WAS CARRIED OUT ABOUT AS FOLLOWS:

Tuesday, September 14th

OPENING SESSION, 10-12 A. M.

Chairman—COL. A. E. WHITE, Chairman Amalgamation Committee
Address of Welcome...HIS HONOR, MAYOR MOORE, of Philadelphia
Response .....COLONEL A. E. WHITE
Appointment of Tellers of Election
Report of the Steel Treating Research Society..PRES. JOHN F. KELLAR
Report of American Steel Treaters' Society.....PRES. T. E. BARKER
Report of Amalgamation Committee.....CHAIRMAN A. E. WHITE
Paper

Papers

H. P. MacDONALD, Vice-President, Sneed & Co., Jersey City, N. J.
"The Electrical Heat Treatment of Steel"
Illustrated by Moving Pictures

Presented by Title

T. F. BAILY, President, The Electric Furnace Company, Alliance, Ohio.
"Relative Economy of Electric, Oil, Gas and Coal-Fired Furnaces"
Report of Tellers

NOONDAY LUNCHEON

Chapter Delegates and National Officers had Luncheon and Business Meeting at Commercial Museum.

Tuesday Afternoon, September 14th, 2 to 4:30

Chairman, COL. A. E. WHITE

Papers

O. E. HARDER, Associate Professor of Metallography, University of Minnesota.
"Microconstituents in One Section of a Metcalf Test Bar"
Illustrated by Lantern Slides.

J. L. McCLOUD, Foreman, Ford Motor Co., Tractor Div., Dearborn, Mich.
"Time, Temperature and Heating Media Functions in Hardening Tractor Worms"
Illustrated by Lantern Slides.

T. D. LYNCH, Research Engineer, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.
"A Process for the Manufacture of Helical Springs for Heavy Duty"

W. G. LOTTES, Steel Expert, International Harvester Co., Chicago, Ill.
"Various Quenching Mediums and Their Application"
Illustrated by Lantern Slides.

Presented by Title

R. B. KERR, Foreman, Heat Treating Department, John Deere Harvester Works, East Moline, Ill.
"Hardening Hammer Die Blocks"

HENRY H. WIEGAND, Vice-President, E. J. Codd Co., Baltimore, Md.
"Furnace Door Screens"

PETER CHAMBERS, Partner, Angelus Steel Treating Co., Redondo, Cal.
"Forging Temperatures"

ROBERT B. POTTINGER, Manager, R. B. Pottinger, Racine, Wis.
"Forging, Welding and Tempering of Light Steel"

J. D. ANDREWS, District Manager, Brown Instrument Co., New York City.
"Pyrometers and Their Application to Steel Treating"

Tuesday Evening, September 14th, 8 to 10

Chairman, J. J. CROWE Chairman, Philadelphia Chapter

Papers

IRA T. HOOK, General Motors Company, Detroit, Mich.
"Factors Limiting the Use of Materials"

F. V. LARKIN, Head of Department of Mechanical Engineering, Lehigh University, South Bethlehem, Pa.
"Lessons Learned in the Manufacture of Munitions and Ordnance that can be Applied to the Peace Time Pursuits of Industry"

GUY P. BIBLE, Salesman, Horace T. Potts & Co., Philadelphia, Pa.
"The Relation of the Steel Salesman to the Development of Heat Treatment of Steel"

V. E. HILLMAN, Metallurgist, Crompton & Knowles Loom Works, Worcester, Mass.
"The Efficiency of Various Quenching Mediums and Their Application"
Illustrated by Lantern Slides

Presented by Title

M. L. HARTMAN, Director Research Laboratory, The Carborundum Co., Niagara Falls, N. Y.
"Carborundum Refractories in Heat Treating Furnaces"

E. F. DAVIS, Sales Manager, Celite Products Company, New York City.
"The Function of Insulation and Its Application to Heat Treating Furnaces"

CHARLES U. GEESEY, Chemist and Metallurgist, The Garford Motor Truck Company, Lima, Ohio.
"The Functions of a Chemist and Metallurgist in the Motor Truck Industry"

J. J. de BOVES, President, Apex Steel Corporation, New York City.
"Heat Treating the Order"

EARL W. PIERCE, Metallurgist, Maxwell Motor Co., Newcastle, Ind.
"The Role of the Metallurgical Laboratory in Relation to the Inspection Department"

Wednesday Morning, September 15th, 10 to 12

Chairman, FRANK FAHY Ex-Chairman of the New York Chapter

CHARLES MORRIS JOHNSON, Director of Research Department, Crucible Steel Company of America, Pittsburgh, Pa.
"Properties and Microstructure of Heat Treated Non-Magnetic, Flame, Acids and Rust Resisting Steel"
Illustrated by Lantern Slides

W. H. MARBLE, Manager, American Stainless Steel Co., Pittsburgh, Pa.
"Stainless Steel, Its Treatment, Properties and Applications"

J. D. CUTTER, Metallurgist, Climax Molybdenum Co., New York City.
"A Suggested Method for Determining the Comparative Efficiency of Certain Combinations of Alloys in Steel"
Illustrated by Lantern Slides

Presented by Title

MARSHALL MEDWEDEFF, Metallurgical Engineer, Samson Tractor Co., Janesville, Wis.
"The Role of the Metallurgical Laboratory in Relation to Inspection"

H. C. LOUDENBECK, Engineer of Materials, Union Switch & Signal Co., Swissvale, Pa.
"Heat Treatment of Steel, Necessary Precautions to Obtain Uniformity"

W. R. WARD, Mechanical and Electrical Engineer, Lyells, Va.
"A Practical Aid to the Treatment of Steel"

NOONDAY LUNCHEON

The Chapter Delegates and National Officers had Luncheon and Business Meeting at the Commercial Museum.

Wednesday Afternoon, September 15th, 2 to 4:30

Chairman, FRANK FAHY

Papers

E. F. COLLINS, Consulting Engineer, Industrial Heating Devices, General Electric Company, Schenectady, N. Y.
"Relative Thermal Economy of Electric and Fuel Fired Furnaces"
Illustrated by Lantern Slides

W. A. EHLERS, Industrial Engineer, American Gas Association, New York City.
"Fuels and Their Application to Metal Treating"

GEORGE H. TROUT, The Smith Gas Engineering Co., Dayton, Ohio.
"Producer Gas for Heat Treating"
Illustrated by Lantern Slides

W. H. LYMAN, General Superintendent, Warner Gear Co., Muncie, Ind., and SETH A. MOULTON, Industrial Furnace Corporation, Boston, Mass.
"Relative Economy of Oil, Gas, Coal and Electric Heated Furnaces"
Illustrated by Lantern Slides

Presented by Title

H. G. HALL, Sales Manager, The Bristol Company, Chicago, Ill.
"The Essentials of Modern Pyrometry"

CARL CHRISTIAN JENSEN, Draftsman, Mahr Manufacturing Company, Minneapolis, Minn.
"The Current in the Thermo-Couple"

Wednesday Evening, September 15th

Chairman, J. FLETCHER HARPER Chairman, Milwaukee Chapter

Papers

T. Y. OLSEN, Tinius Olsen Testing Machine Company, Philadelphia, Pa.
"Most Recent Developments in Testing Machines and Equipment for Metallurgical Use"
Illustrated by Lantern Slides

E. P. STENGER and B. H. STENGER, Metallurgical Engineers, Thompson & Black, Detroit, Mich.
"The Effect of Heat Treatment on the Fatigue Strength of Steel"
Illustrated by Lantern Slides

ERIC E. BILGART, President, Pyromagnetic Instrument Co., Chicago, Ill.
"The Advantages of Magnetic Forces in Heat Treating"

Presented by Title

JAMES B. MOREY, Foreman of Annealing in Wire Mill, Atlas Crucible Steel Company, Dunkirk, N. Y.
"The Efficiency of Various Quenching Mediums, with their Practice and Applications"

ARTHUR N. ARMITAGE, Mesta Machine Company, Pittsburgh, Pa.
"The Pyrometer from the Standpoint of the User"

Thursday Morning, September 16th, 10 to 12
Exhibition Open from 9 to 5 P. M.

NEW YORK DAY

Chairman, WALTER GRAHAM Chairman, New York Chapter

Papers

G. R. BROPHY and Miss S. B. LEITER, Metallurgists, General Electric Co.,

Research Laboratories, Shenectady, N. Y.

"The True Action of Cyanide in Case Hardening Steel"

Illustrated by Lantern Slides

T. G. SELLECK, Alfred O. Blaich Company, Chicago, Ill.

"Case Hardening"

Illustrated by Lantern Slides

G. S. McFARLAND, Metallurgist, Jeffrey Manufacturing Co., Columbus, Ohio.

"A Research in Case Carbonizing"

Illustrated by Lantern Slides

R. L. GILMAN, Experimental Heat Treater, Standard Steel and Bearing Co., New Haven, Conn.

"Carburizing, Hardening and Tempering High Carbon Alloy Steels in One Hundred and Thirty Minutes"

Presented by Title

C. A. HAUX, Foreman, Avery Company, Peoria, Ill.

"Carburizing Temperatures Best Suitable for Steels of Various Carbon Contents"

FRANK J. McINTYRE, In Charge of Pyrometers, Hayes Wheel Company, Jackson, Mich.

"Practical Facts on Pyrometry"

A. BENSEL, First Vice-President, Driver-Harris Co., Harrison, N. J.

"High Temperature Resisting Alloys for Carbonizing"

WILLIAM G. CONNER

"The Carbonizing of Cast Steel Parts, Gears, Clutches, Etc."

Thursday Afternoon, September 16th, 2 to 4:30

Chairman, WALTER GRAHAM Chairman, New York Chapter

Papers

H. J. FRENCH, Bureau of Standards, Washington, D. C.

Moving Pictures of the Department of Metallurgy of the Bureau of Standards

J. L. THORNE, Metallurgist, U. S. High Speed Steel and Tool Corp., New York.

"Heat Treatment of High Speed Steel"

A. H. D'ARCAMBAL, Chief Metallurgist, Pratt & Whitney Co., Hartford, Conn.

"The Hardening of High Speed Steel"

Illustrated by Lantern Slides

Presented by Title

A. F. MacFARLAND, Metallurgical Engineer, Vanadium Alloys Steel Co., Latrobe, Pa.

"High Speed Steel and Some of Its Problems"

HENRY TRAPHAGEN, Metallurgist, Fast Feed Drill and Tool Corp., Toledo, Ohio.

"The Selection of High Speed Steel for Tools"

GEORGE PORTEOUS, Supervisor of Forge and Heat Treatment, Minnesota Steel Company, Duluth, Minn.

"High Carbon Open Hearth Steel Versus Crucible Tool Steel in the Manufacture of Miscellaneous Tools"

CHARLES N. RING, Chief Chemist, Ohio Steel Foundry Co., Springfield, Ohio.

"The Annealing and Heat Treatment of Miscellaneous Steel Castings"

HENRY E. HEMSTREET, General Foreman, Spring Department, Sheldon Axle and Spring Company, Wilkes-Barre, Pa.

"Heat Treatment of Truck Axles"

Friday, September 17th
Exhibition Open 9 A. M. to 5 P. M.
PLANT VISITATION

The following plants were open for visitors on Friday morning, from 9 to 12 o'clock:

Leeds & Northrop Co., 4901 Stenton Avenue—Pyrometers, Electric Furnaces, Electric Measuring Instruments, etc.

Edward G. Budd Manufacturing Company, 25th Street and Hunting Park Avenue—Automobile Bodies, Steel Stampings, etc.

Hess-Bright Manufacturing Company, Front Street and Erie Avenue—Annular Ball Bearings. S. K. F. Metallurgical and Research Laboratory.

AFTERNOON

The following plants were visited on Friday afternoon:

League Island Navy Yard, Hog Island, Midvale Steel and Ordnance Company.

LADIES' PROGRAM

The headquarters for the ladies was on the first floor of the Bellevue-Stratford Hotel, Rooms 108 and 109. A Secretary was at headquarters all the time to give information and for registration purposes.

Mrs. Bullens and her committee had arranged a very attractive program and the 75 ladies in attendance were very happy they had come.

The events were as follows:

Tuesday, September 14th

11:00 A. M.—Philadelphia ladies received out-of-town guests at Headquarters, first floor of the Bellevue-Stratford Hotel.

12:00 M.—Luncheon, Roof Garden, Bellevue-Stratford Hotel.

2:30 P. M.—Sight-seeing auto tour of Philadelphia, stops being made at Independence Hall to see the Liberty Bell, Declaration Chamber, etc., and also at the United States Mint. Points of interest include Historical, Business and Residential sections, including portion of Fairmount Park.

8:00 P. M.—Theatre party at Keith's.

Wednesday, September 15th

About 10:00 a. m. the ladies left on an all-day sight-seeing trip (auto) to Valley Forge, via Fairmount Park, Overbrook, Wynnewood, Bryn Mawr, etc. Ample time to enjoy historical Valley Forge.

At noon the ladies enjoyed the world-famous Pennsylvania Chicken and Waffle Dinner at Washington Inn, Valley Forge. Sight-seeing continued, returning about 4:00 p. m., arriving Philadelphia, 5:30 p. m.

Evening—Movie—Civilian Clothes.

Thursday, September 16th

Organ Recital at Wanamaker's Store at 11 o'clock and personally conducted tour of the store.

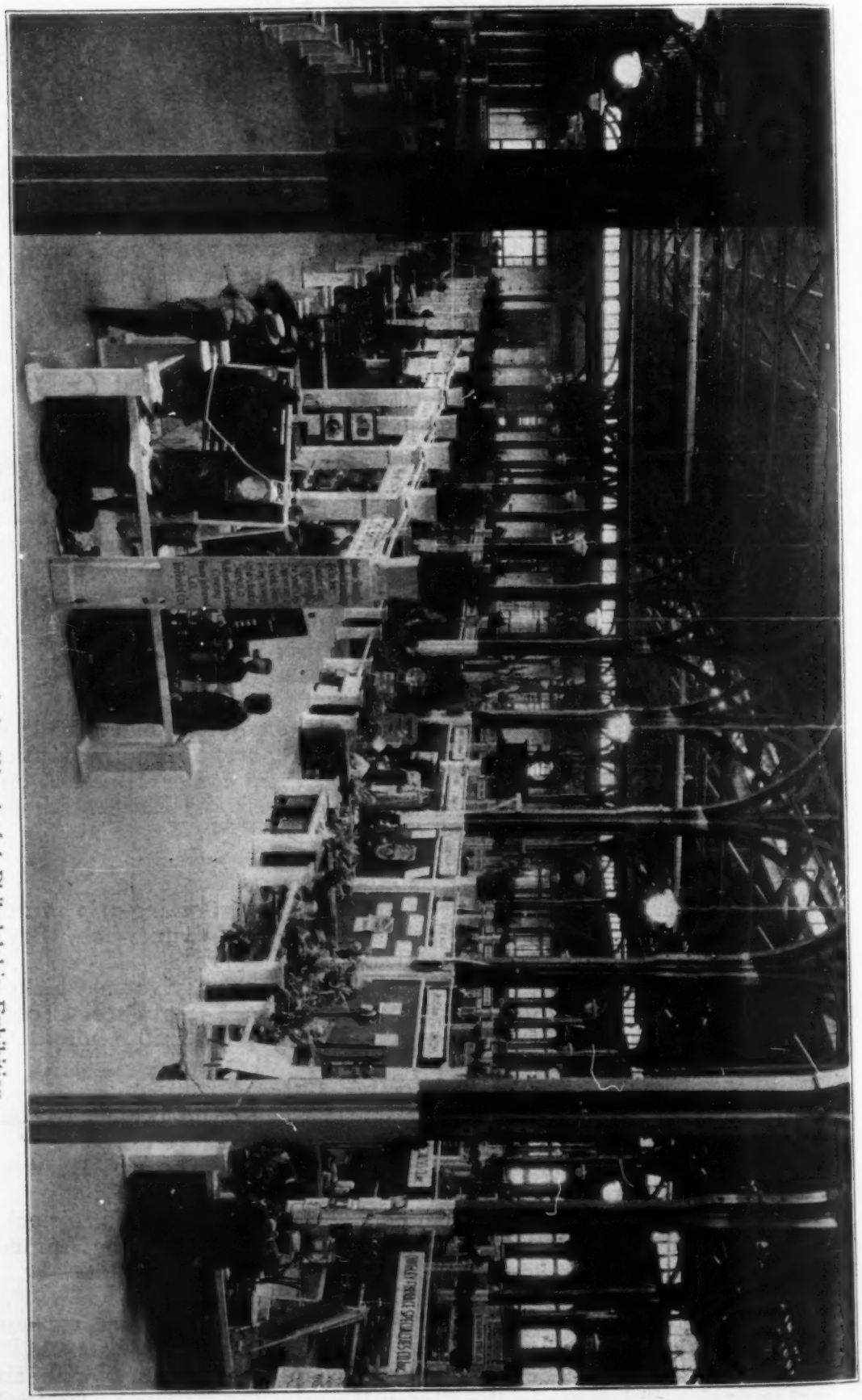
Visit the Curtis Publishing plant and trip to the Commercial Museum to inspect the exhibits.

Evening, 6.30 o'clock—Shore Dinner at Boothby's. 8:45 o'clock, Ladies joined men in time for speeches and entertainment at the Annual Banquet of the Society, Grand Ball Room, Bellevue-Stratford Hotel.

Friday, September 17th

Personally conducted trip to the Navy Yard and visit on various destroyers, battleships and submarines and several ex-German U-boats.

Evening, 8:00 o'clock—The Philadelphia Chapter entertained with an informal reception and dance in the Clover Room of the Bellevue-Stratford Hotel.



A view of one of the ten sections of the Wonderful Philadelphia Exhibition

LIST OF EXHIBITORS AT CONVENTION

Advance Furnace & Engineering Co., Springfield, Mass. Booths Nos. 134-135.

Ajax Electrothermic Corp., Trenton, N. J. Booth No. 301.

Alan Wood Iron & Steel Co., Philadelphia, Pa. Booths Nos. 251-252.

American Gas Association, New York. Booth No. 145.

American Gas Furnace Co., New York. Booths Nos. 131-132.

American Metallurgical Corporation, Philadelphia, Pa. Booth No. 75.

Armstrong Cork & Insulation Co., Pittsburgh, Pa. Booths Nos. 194-195.

Atlas Crucible Steel Co., Dunkirk, N. Y. Booths Nos. 9-10.

Bausch & Lomb Optical Co., Rochester, N. Y. Booths Nos. 139-140.

Bell & Gossett Co., Chicago, Ill. Booth No. 205.

Bennett Co., W. R., Elmwood, Conn. Booth No. 137.

Bethlehem Steel Co., Bethlehem, Pa. Booths Nos. 61-62-235-236

Blaich & Co., Alfred O., Chicago, Ill. Booths Nos. 63-233.

Bristol Co., Waterbury, Conn. Booth No. 175.

Brown, Clair H., Detroit, Mich. Booth No. 144.

Brown Instrument Co., Philadelphia, Pa. Booths Nos. 245-246.

Buda Co., Chicago, Ill. Booth No. 8.

Bureau of Standards, Washington, D. C. Booths Nos. 190-191.

Carborundum Co., Niagara Falls, N. Y. Booth No. 296.

Case Hardening Service Co., Cleveland, Ohio. Booth No. 204.

Celite Products Co., New York City. Booth No. 104.

Chemical & Metallurgical Engineering Co., New York City. Booth No. 226.

Chicago Chapter, A. S. S. T. Booth No. 1.

Chicago Flexible Shaft Co., Chicago, Ill. Booth No. 295.

Codd Co., E. J., Baltimore, Md. Booth No. 299-B.

Crucible Steel Co. of America, Philadelphia, Pa. Booth Nos. 273-276-277-280.

Dearborn Chemical Co., Chicago, Ill. Booth Nos. 87-200.

Disston & Sons, Henry, Inc., Philadelphia, Pa. Booth Nos. 89-198.

Driver-Harris Co., Harrison, N. J. Booth No. 133.

Electric Furnace Construction Co., Philadelphia, Pa. Booth No. 258.

Engelhard, Charles, New York, N. Y. Booth No. 297.

Fast Feed Drill & Tool Corp., New York. Booth No. 14.
Federal Tool & Alloy Steel Corp., New York. Booth Nos. 227-230.
Ferguson Furnace Co., Toledo, Ohio. Booth No. 228.
Ford Chain & Block Co., Philadelphia, Pa. Booth No. 80.
Frasse Steel Corp., Booth Nos. 117-118.

General Electric Co., Schenectady, N. Y. Booth Nos. 3-4.
Griscom-Russell Co., New York. Booth No. 244.

Hagan Co., George J., Pittsburgh, Pa. Booth Nos. 173-174.
Halcomb Steel Co., Syracuse, N. Y. Booths Nos. 188-189-192.
Haynes Stellite Co., New York City. Booth Nos. 170-167.
Heppenstall Forge & Knife Co., Pittsburgh, Pa. Booth No. 41.
Heinemann Electrical Co., Philadelphia, Pa. Booth No. 292.
Holz & Co., Inc., New York. Booth Nos. 248-249.
Hoover Steel Ball Co., Ann Arbor, Mich. Booth No. 15.
Hoffman Products Co., Harrisburg, Pa. Booth No. 11.
Hoskins Mfg. Co., Detroit, Mich. Booth Nos. 259-260.
Houghton & Co., E. F., Philadelphia, Pa. Booth Nos. 217-218.
Hungerford Brass & Copper Co., Philadelphia, Pa. Booth No. 256.

Improved Appliance Co., Booth No. 268.
Industrial Press, New York. Booth No. 150.
Ingersoll-Rand Co., Phillipsburg, N. J. Booth No. 149.
Iron Age Publishing Co., New York City. Booth Nos. 281-282.

Jones & Co., B. M., Inc., New York City. Booth No. 294.

Latrobe Electric Steel Co., Latrobe, Pa. Booth Nos. 275-278.
Leeds & Northrop Co., Philadelphia, Pa. Booth Nos. 68-214-215-216.
Leitz, E., Inc., New York. Booth No. 279.
Ludlum Steel Co., Watervliet, N. Y. Booth Nos. 185-186.

MacLeod Co., Cincinnati, Ohio. Booth No. 48.
Mahr Manufacturing Co., Minneapolis, Minn. Booth No. 222.
Mesta Machine Co., Pittsburgh, Pa. Booth Nos. 34-271.
Maxon Furnace & Engineering, Muncie, Ind. Booth No. 301.
Metal & Thermit Corp., New York, N. Y. Booth Nos. 242-243.

Midvale Steel & Ordnance Co., Cambria Steel Co., Philadelphia, Pa. Booth Nos. 77-78.

Milburn Co., Alexander, Baltimore, Md. Booth No. 81.

Modern Equipment Co., Taunton, Mass. Booth Nos. 49-50-51-52. Temperature control.

Montgomery Chemical Co., Detroit. Booth No. 203.

National Iron & Steel Publishing Co., Pittsburgh, Pa. Booth No. 247.

Oakley Chemical Co., New York City. Booth No. 241.

Obermayer Co., S., Pittsburgh, Pa. Booth No. 123.

Onondaga Steel Co., Inc., Syracuse, N. Y. Booth No. 206.

Paxson, J. W., & Co., Philade'phia, Pa. Booth No. 224.

Penn Seaboard Steel Co., Philadelphia, Pa. Booth Nos. 237-240.

Penton Publishing Co., Cleveland, Ohio. Booths Nos. 5-6.

Philadelphia Chapter, A. S. S. T. Booth No. 2.

Philadelphia Electric Co., Philadelphia, Pa. Booth No. 203.

Pittsburgh Inst. & Mach. Co., Pittsburgh, Pa. Booth No. 143.

Potts & Co., Horace T., Philadelphia, Pa. Booth No. 193.

Pyro Magnetic Instrument Co., P. O. Box 723, Chicago, Ill. Booth No. 287.

Quigley Furnace Specialties Co., New York. Booth Nos. 207-208-209-210.

Railway Mechanical Engineer, Woolworth Bldg., New York. Booth Nos. 211-212-213.

Riehle Bros. Testing Machine Co., Philadelphia, Pa. Booth Nos 95-180-179.

Rockwell Co., W. S., New York City. Booth No. 88 and 197.

Rodman Chemical Co., Verona, Pa. Booth Nos. 283-284.

Roessler & Hasslacher Chemical Co., New York. Booth No. 187.

Rohde Laboratory Supply Co., New York City. Booth No. 178.

Scientific Materials Co., Pittsburgh, Pa. Booth Nos. 220-221.

Selas Co., New York City. Booth No. 291.

Shimer & Son, Porter W., Easton, Pa.. Booth No. 146.

Simonds Steel Mills, Lockport, N. Y. Booth No. 196.

S. K. F. Industries, Philadelphia, Pa. Booth No. 42.

Smith Gas Engineering Co., Dayton, Ohio. Booth No. 96.

Spencer Turbine Co., Hartford Conn. Booth No. 285.

Spring Perch Co., Box A, Stratford, Conn. Booth No. 257.

Standard Fuel Engineering Co., Detroit, Mich. Booth Nos. 181-182.

Steel City-Testing Laboratory, Pittsburgh, Pa. Booth No. 250.

Steel Treating Equipment Co., Detroit, Mich. Booth No. 289.

Steuben Truck Co., Cincinnati, Ohio. Booth No. 257.

Strong, Carlisle & Hammond Co., Cleveland, Ohio. Booths Nos. 299A-300.

Supplee-Biddle Hardware Co., Philadelphia, Pa. Booth No. 138.

Surface Combustion Co., New York City. Booth No. 136.

Swind Machinery Co., Philadelphia, Pa. Booth Nos. 35 and 272.

Tate Jones & Co., Inc., Pittsburgh, Pa. Booth No. 130.

Taylor Co., N. & G., Philadelphia, Pa. Booth Nos. 22-23.

Thomas Co., Arthur H., Philadelphia, Pa. Booth Nos. 141-142.

Thwing Instrument Co., Philadelphia, Pa. Booth No. 176.

Tinius Olsen Testing Machine Co., Philadelphia, Pa. Booth Nos. 64-231-234.

U. S. High Speed Steel & Tool Corp., New York City. Booth Nos. 73-74.

Vanadium Alloys Steel Co., Latrobe, Pa. Booth No. 201.

Van Nostrand Co., D., New York. Booth No. 71.

Ward's Sons Co., Edgar T., Philadelphia, Pa. Booth No. 219.

Wayne Oil Tank & Pump Co., Fort Wayne, Ind. Booth No. 298.

Wheelock Lovejoy & Co., Inc., Cambridge, Mass. Booth Nos. 183-184.

Widney Test Laboratories, Chicago, Ill. Booth No. 69.

William Ganschow Co., Chicago, Ill. Booth No. 102.

Wilson-Maeulen Co., New York City. Booth Nos. 76-79.

Yarnell-Waring Co., Philadelphia, Pa. Booth No. 37.

EXPRESSIONS

It is always interesting to know how the exhibitors feel towards an exposition after it is over. We should remember they are all keen, wide awake business men who have authorized an advertising expenditure and in many cases have spent thousands of dollars to make a display. If you will read the following you will acquire an inkling into the brain activity of big business. Other opinions will be published later:

Mr. W. G. Barstow, of the Mahr Mfg. Company:

It pleases us to state that the results obtained from the exhibit of the Mahr Mfg. Company's equipment at the Philadelphia Convention, eclipses those obtained at the 1919 show at Chicago, which was, at that time, probably the most successful exhibit we have ever put on.

Mr. Earl Converse, of the Dearborn Chemical Company:

It is a great advancement over the Convention in Chicago, and I believe we have received more real benefit and good, coming in contact with more people really interested in our line, than we have in many previous Conventions which we have attended in 35 years, which goes to show that this industry is of such vital importance in bringing together the control departments of steel manufacturers with their managers and owners.

Mr. W. F. Scully, Advance Furnace & Engineering Company:

From the viewpoint of our Company, the exhibition has been an entire success. We obtained an order for the new type of moving floor furnace which we exhibited, and have prospects for at least 25 more. Also obtained several propositions for complete oil and gas furnace systems for our standard furnaces. We are all very glad we exhibited.

Mr. G. L. Reichhelm, American Gas Furnace Company stated:

I think that the officers should be congratulated on the wonderful success of the Convention. We never exhibited at a show where the inquiries came from such an intelligent class of men seeking our products. The benefits which we have received far outweigh the comparatively slight expense of the show.

We have sold a number of furnaces and would have sold a great many more if we had been prepared to make deliveries.

Mr. J. B. Shelby, Driver Harris Company:

The Driver Harris Company desire to express their appreciation to the officers of the Convention for their co-operation in arranging this particularly beneficial exhibit. We feel particularly gratified at the class of exhibitors who have inquired at our booths regarding our various products.

We look forward to a continuance of these Conventions, and are arranging to be suitably represented again next year.

It seems an excellent opportunity for reaching the class of people and the particular individuals whom we wish to interest in Cast Nichrome and its heat resisting qualities.

Mr. Myall, Supplee Biddle Company:

Speaking for the Supplee Biddle Company of Philadelphia, we can say without hesitation, that we have had a highly successful week. Our booth has been well patronized, and we have lined up important pros-

pects for a considerable volume of business. Be assured that we will be one of your exhibitors at your next Convention.

Mr. A. R. Beves, Surface Combustion Company, states:

I feel that the Exhibition was highly successful. Many very interesting inquiries, those from old customers and from interested parties have been received, and also orders have been secured direct through our exhibit at this Convention. I feel we will be very greatly interested in having an exhibit at the Convention next year.

Mr. E. E. Bilgart, of the Pyromagnetic Instrument Company states that although it was their first exhibit, the benefits derived therefrom were very much beyond expectations. We feel that it affords both those interested in the art of heat treating as a commercial item, and those interested from a business standpoint, an opportunity of discussion as to the adaptability of methods, materials and inventions. It brings the salesmen in contact with the very men he wants to meet. This exhibit has given us an opportunity of making new acquaintances. We have received orders for over 11 Pyromagnetic Indicators, and have prospects for a great many more orders.

Mr. F. A. Calhoun, Eastern Representative, Standard Fuel Engineering Company:

It is the opinion of the writer and his associate, Mr. Baad, that the Exhibition and Convention of the American Society for Steel Treating has been very successful in helping us meet new customers and receiving many inquiries. All of the people who have visited us, came to the Convention with one purpose in mind and that was to look into the matter of a purchase of heat treating equipment.

Mr. Trout, Smith Gas Engineering Company:

I wish to congratulate the officers of the Society in having had such a turnout of high quality men at the Convention, rather than a large body who were merely curiosity seekers. Ninety per cent of the people who called at our booth, were people who talked intelligently and were highly interested.

Mr. W. G. Sours, of the Riehle Brothers Testing Machine Company:

We feel that the show from a standpoint of our line of testing machines has been very successful to us. We have had many visitors examine our working demonstrations, and they have shown an intelligence on the proposition which speaks well for the class of people in attendance. In addition to that, we have received many prospects for future business, and we are sure that these will materialize.

Mr. Durgin, of the Modern Equipment Company:

I was very much pleased with the class of people who have examined our exhibition, due to the fact that the sightseers were absent. We have secured a large number of excellent prospects and feel sure that we will be able to close many of them.

Mr. W. C. Tyler, of the Wm. Ganschow Company:

The Exhibition from the standpoint of inquiries and prospects of

future orders, has been more successful than we anticipated. I feel sure that these will materialize into business that will more than pay for the expense of two booths instead of the one that we had.

Mr. Gossett, of the Bell-Gossett Company:

The Exhibition has been more than gratifying. Many orders have been received, and the prospects are very excellent.

Mr. C. C. McDermott, of the Brown Instrument Company, states:

The inquiries and sales we have received and made at the Convention have been far greater than we expected. The attendance has seemed to be of the buying variety, and not many curiosity seekers. Not only good volume in attendance but good quality.

Mr. H. H. Harris, Quigley Furnace Specialties Company, states:

We have exhibited at over 50 Conventions, and we do not know of any Convention with the possible exception of the Foundrymen's Convention, where we have derived more benefit. The majority of the visitors at our booths were executives and officers of their companies, and we had very few idlers or people who could not be considered as prospects.

We had over 2,000 visitors and handed out more than 400 samples of Q-Alloys, each of which we received a signed receipt for. In all we consider our time and money well spent, and firmly believe that the American Society for Steel Treating has made further progress in two years than any other similar organization. We give our heartiest support to the Society and its every enterprise.

Mr. Wooler, Philadelphia, representative of Strong, Carlisle & Hammond Company, stated:

I was highly gratified by the excellency of those in attendance, inasmuch as they were men who had been sent by the Purchasing Departments to investigate the furnaces and to make reports. There is no doubt that it is the most reasonable method possible to secure get in contact with the users.

Mr. Lazear, of the Chicago Flexible Shaft Company:

My opinion of the show is that the crowds that came in were actually interested. The man that came to the show, came because he was interested in heat treating. We had comparatively few curiosity seekers. We have secured a large number of good prospects. It is my opinion that the show is worth ten times what the expense cost us.

Mr. Wiegand, of E. J. Codd Company:

I think that the show has been a great success. We have reached the very people we want to meet, and no curiosity seekers. We have received a great deal of interest in the Chain Furnace Doors and have a large list of prospects.

Mr. K. P. Himley, Selas Company:

I am very glad we exhibited at this Convention, as we were able to see the very men that we were anxious to meet, such as the Metallurgists and Managers of the plants. We have secured a large list of prospects, which will no doubt result in good business.

Mr. H. Goldsen, Wilson-Maeulen Company:

I think the Exhibition was a show that only those who were actually interested in their line of business came to see. They came to see how to better their product. We have made more actual orders for Pyrometers and Rockwell Hardness Machines than we ever dreamed of getting.

Mr. F. G. Davis, Atlas Crucible Steel Company:

The Convention at Philadelphia was undoubtedly a wonderful success. We are highly pleased with the results of our exhibit, and are confident that there will be a very material increase in our business in the very near future as a direct result of this Convention. We have met the very men we have wanted to meet.

Mr. R. E. Talley, George J. Hagan Company:

We had Presidents of big concerns come in and sit in our booth for over an hour, who were interested in our furnaces. The people who attended the Convention were interested and not curiosity seekers or souvenir hunters. We secured many good prospects, 80 per cent of which are good and will develop into future business.

Mr. Ray, Heppenstall Forge & Knife Company:

We feel well paid for the labor and expense that we have gone to, to install a booth at the Convention, and it is my personal opinion that at the next Convention we should be represented in a more thorough manner than this year.

There were no souvenir hunters, but every one who stopped at our booth, were either customers or prospective customers, and were interested in die blocks and the heat treatment of same.

THE FUNCTION OF INSULATION AND ITS APPLICATION TO HEAT TREATING FURNACES

E. F. Davis*

A paper read before American Society for Steel Treating Convention, Sept., 1920

The urgent needs of the government for various furnaces, during the World's War which has been brought to a successful end, resulted in many types of furnaces being hurriedly designed and placed in operation. Quantity rather than quality predominated in the minds of furnace designers. But the scarcity and steadily rising cost of fuel of all kinds, the increased operating costs, and keen competition during the past few years has stimulated interest on the part of manufacturers to increase the efficiency of all manufacturing operations and the industrial world's attention has been drawn to many losses in heat treating which heretofore were neglected. Prominent among these is the loss of heat through furnace walls.

Every manufacturing concern is carefully searching and investigating every process and method that would tend to be an economical solution to his fuel problem.

During the past few years the manufacturers have had to meet a constant increase of cost for fuel and also great difficulty in some cases to get it at any price, therefore, if the manufacturer is able to increase the efficiency of his furnaces by the better utilization of his fuel he will then be able to keep his fuel cost per unit of output nearly constant.

Many old theories in furnace design have been forced to give way to more modern practice of producing a specified product and the manufacturer has learned that indifferent heating with any old kind of a furnace would not give a product that would meet modern heat treating specifications.

The most important progress has been made in furnace design, insulation, durability, economical applications of heat, furnace control and ease of operation.

Burners have been designed providing a definite known mixture of fuel and air which has done away with the evils and the loss due to improper combustion. The control of products of combustion by means of flues and dampers properly located, have added greatly towards uniformity of heat. This has in many cases replaced the old methods of allowing the flame to come directly in contact with the steel causing heavy oxidation and uneven heating.

For many years it has been a well recognized fact that heat, and hence fuel were being lost through the furnace walls, but until recently it was not known how much this loss amounted to in dollars and cents; nor was it known that the larger part of this loss could be eliminated by the use of an efficient and durable insulating material.

The first and most important step for the conservation of fuel is to insulate the space being heated.

Inasmuch as the heat loss of any heat treating furnace is a function of the size of the exposed surface and hence of the size of the heated space, it follows that the appliance should be well adapted to the work to be done as to its size.

Intimate knowledge of materials suitable for construction of heating devices is important so that in all cases the material most suited for

*Sales Engineer Celite Products Co.

the purpose is selected and the amount of heat absorbing material is limited to that required for strength and durability.

If an oven is constructed with little or no insulation, the heat loss through its walls is great and the expense of the fuel is considerably larger. If this same oven is insulated the heat loss is materially decreased.

It can be mathematically proven that the maximum economy obtained when the cost of the heat loss for a given period of time is equal to the fixed charges of the additional expenditure for heat insulation for the same period of time. For given conditions of price of fuel and heat insulating materials, the working temperature and the load factor of the oven, the amount of heat insulation required for maximum economy can therefore be readily determined.

It often happens that a furnace is built of twice the capacity of its predecessor and upon completion of same it is discovered that the larger furnace has more uniform temperature throughout and also requires considerably less than twice the amount of fuel to keep it running.

The reason for same being not owing to the heavier construction but also that the holding capacity of a furnace increases approximately as the cube of the linear dimensions, while the radiating surface increases as its square, so that loss from radiation is less than twice the primary amount from the furnace of double capacity.

From this it will readily be seen that not only will furnace efficiency vary between the different types but also between the same type according to their size, design and the process carried on within them.

If the refractory material used possesses a fusion point or softening range higher than the maximum temperature to which they are exposed, (which is always the case in heat treating furnaces) it would be most

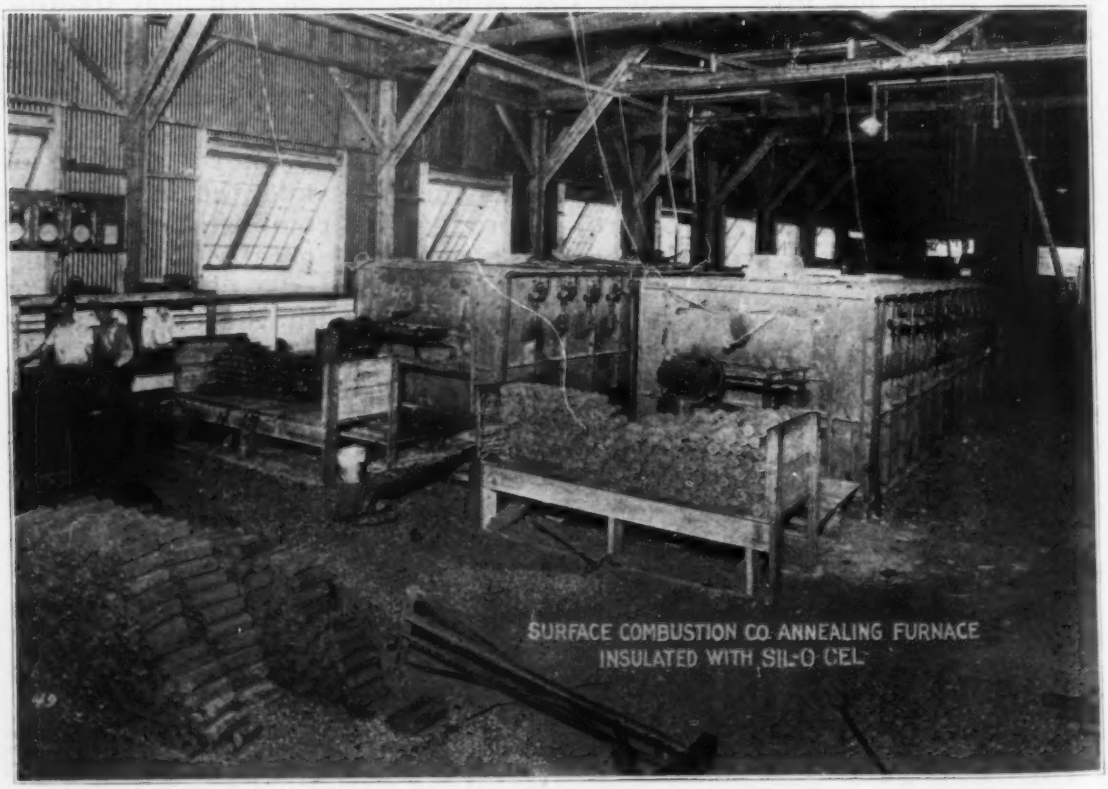


Figure 1

desirable that they should be backed up with materials which are non-conductors of heat, for radiating losses would then be at a minimum.

It is readily seen that quicker heats can be made where the temperature is uniform. The temperature being equal throughout the furnace, the rate of heat absorption is alike throughout the charge.

A large amount of rejected work that is charged to bad steel or the heat treating department can often be traced to poor heating in the forging process. If the metal is not heated uniformly throughout the mass it cannot flow evenly under the flows of the hammer or between the dies of the press, consequently the grain is not closed in a uniform manner. If the furnace temperature is easily controlled, disastrous over heating of the charge is minimized.

A definite amount of heat is required for raising the temperature of

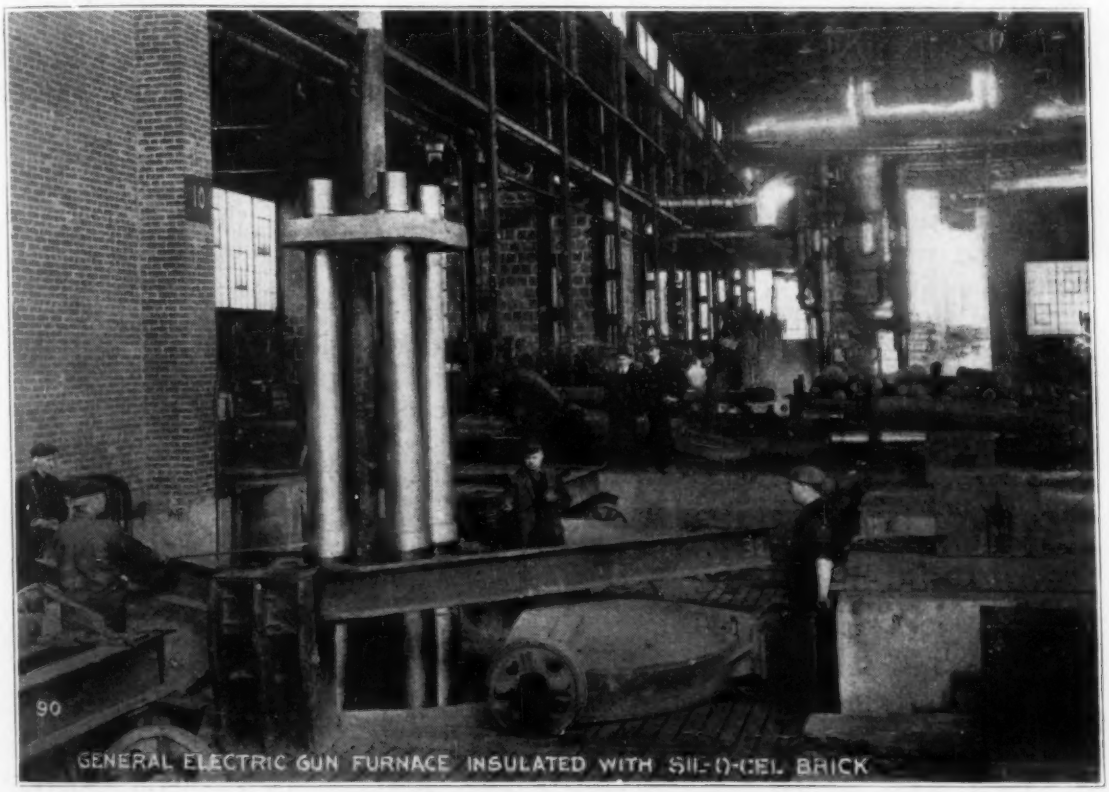


Figure 2

the work through a given range, irrespective of the length of time consumed in heating. However, with a given amount of material being heated through a definite range and consuming a definite amount of fuel, if the heating is accomplished in one half the time double the amount of fuel will be required.

The total weight of the work heated, multiplied by the degrees rise in temperature multiplied by the specific heat of the metal gives the amount of fuel required in B. T. U. The specific heat of iron which is the heat in B. T. U. required to raise 1 lb. 1° F. is 0.125.

Efficiency

The efficiency of a heat treating furnace is expressed by the ratio of heat supplied to heat usefully applied in the furnace.

$$\frac{\text{Heat usefully applied}}{\text{Heat supplied}} = \text{efficiency of furnace}$$

The heat usefully applied is governed by four requirements.

1. Heat necessary to raise the temperature of the charge to the point at which the desired reaction takes place.
2. Heat to balance reaction if reaction is endothermic.
3. Loss from stack through the producers of combustion according to the fuel in use.
4. Loss through the wall through conduction which is dissipated by radiation and conduction varying according to the construction.

Heat Conservation

Many combustion furnaces in use today suffer from overventilation as the result of improperly proportioned flues or vents. In such cases the draft is so excessive that the hot gases of combustion are carried through the furnace at a speed so great that no opportunity is allowed for them to give up much of their available heat, which is thus carried away with the flue gases and lost to useful work.

When the proper precautions are not taken much heat is lost by conduction through, and radiation and convection from, the furnace walls to the room. When it is desired to concentrate all of the possible heat upon the work in the furnace and an appreciable amount of this heat is lost in this manner, low efficiency is the result.

The flow of heat through bodies by conduction may be either a help or a hindrance, according to the use to which we put the material. In some cases it is desired to conduct heat as quickly as possible; in others it is desired to lessen or prevent the conduction of heat as much as possible. Copper tubing is introduced into a water heater so that heat energy may be conducted through the walls of the tube to the water within as quickly as possible.

We cover the outside boilers with lagging in order to keep heat from being conducted away. Here we want a poor conductor of heat and we say we have used an "insulator."

There is perhaps no field in which neglect of simple economies is more prevalent than in the field of heat insulation, and the manufacturer and superintendent of the heat treating departments should give the insulation of their heat treating equipment careful consideration in the building or selecting of their furnaces for future work.

Each new application presents a new engineering problem and requires investigation of present equipment. When these are determined the accurate data available on the most advisable fuel will allow a thorough comparison to be made on a commercial basis which represents the factor of interest to manufacturers. These investigations will also determine whether the application of the fuel will be a success from an operative view. It isn't very comforting to know that you have an apparatus capable of operating well and find after it is installed that it is not applicable to your requirements or represents no saving.

While the success of any installation demands a well designed apparatus, the important factor in the consideration of such an installation is whether the installation is really warranted, and if so, the proper application of the fuel to its most economical use.

Heat Transmission

In connection with a discussion of insulation, brief mention of heat

transmission is of interest, furnishing as it does, the fundamental considerations that govern insulating work.

Heat is a form of energy consisting of molecular vibration of a periodic character, subject to the general laws of wave motion. It can be reflected, refracted and dispersed by creating the proper condition within the walls. In other words, we can increase or decrease the rate of heat flow within certain limits, by altering the design and the materials of construction of the walls.

Heat is transferred from one place to another by three different methods—conduction, radiation, and convection.

Conduction is the action taking place in which heat energy is passed from a particle at a higher temperature to one at a lower temperature by virtue of their contact. While this method of heat transfer applies to the three states of matter—solid, liquid and gaseous—it is of magnitude only in solids.

By radiation heat is transferred from one body to another without any material agency by wave motion, this applies only to the gaseous state of matter.

Convection is the process of heat transfer in which some portion of the body whose temperature is raised moved to another place where the temperature is lower, tending to raise the temperature of the medium. This method of transfer is limited, therefore, to liquids and gases.

Taking a simple example of the application of these methods, as, for instance, a furnace wall, the heat is transmitted from the combustion chamber by radiation direct from the burning fuel to the inner surface of the firebrick walls, and by convection currents resulting from the moving gaseous product of combustion. Following the heat passes through the walls, and, ultimately is lost by radiation from the outer surface enhanced by convection caused by air movement outside of the wall.

Conduction is responsible for the greatest portion of the heat transmitted, through the furnace walls. The rate of this conductivity through the wall depends upon the ability of the materials used in construction to resist the movements of the heat waves. This immediately applies to our consideration of the matter of wall insulation, for without proper insulation the heat losses assume a surprising total in the aggregate—an amount of actual fuel loss that often is not appreciated.

Rate of Heat Flow

The amount of heat conducted through a unit area from one part of the body to another is proportional to the thermal conductivity of the body through which the heat passes and inversely proportional to the distance between the two parts of the body. In other words, the conduction of heat through a solid body from one place to another is a direct function of the conductivity of the body and the difference in temperature of the two planes, and an indirect function of their distances apart. This is identical with Ohm's law for transfer of electrical energy.

The heat transferred from one body to another by radiation is proportional to the difference of the fourth powers of the absolute temperatures of the two bodies. While this is strictly true only of the ideal "black-bodies" the variation is so small that, for all practical purposes, this relation holds good in ordinary procedure.

Requirements of Insulators

The requirements of the insulating backing for the more refractory

lining is rather severe. An ideal material should have the value, and be sufficiently refractory so that no fusing or excessive shrinkage would take place in that portion which is in direct contact with the highly heated refractory wall. It should not be decomposed or be changed greatly in volume at the temperature, and it should, furthermore, be of light weight, unaffected by moisture, of convenient form, readily applied by unskilled labor and low in cost. It should be of such composition as not to react upon or attack either the refractory material or the metal shell of the container, even in the presence of moisture; i. e., it should contain no free acid radicals, and should not be broken or caused to settle by vibration or heat. It should not have high expansion, and it should be sufficiently elastic to take up strains between the lining and the shell produced by temperature changes.

While this is a rather formidable array of requirements, there are products upon the market which fulfill practically all of them.

Selection of Insulation

In any high temperature apparatus, if the heat can be prevented from being dissipated from the outside of the furnace, the temperature of the furnace is made more uniform in the zone of reaction, and consequently the capacity is manifestly increased without additional fuel consumption. Furthermore, overheating at the source of heat in the effort to bring as much of the furnace as possible into the zone of reaction, is materially reduced by preventing loss through the furnace walls. This has the ultimate effect of lowering the temperature at the source of heat, greatly increasing the life of the refractories and the capacity of the furnace.

In general the question of insulation does not concern itself so much with the saving in fuel, though this is also an important item, as with the general effect produced by confining the heat generated to points of maximum effectiveness. The higher the cost of fuel the more necessary it is to look closely to preventable losses to obtain an economically operated furnace.

By the use of an insulating material such as Sil-O-Cel, heat treating besides assuring a degree of quality that cannot be otherwise attained owing to the even temperature maintained throughout the furnace is really more economical than the methods generally used. The fuel economy is greater, the operation is more convenient through absence of temperature fluctuations, and the speed of heating is considerably increased.

This follows because heat is definitely applied to all sides of the charge at once so that very little soaking is required beyond the time necessary to bring the charge up to the required temperature. In furnaces which have no insulation and where the heat is not evenly applied, a long soaking period is required to assure a fair measure of uniformity, by heat travel through the material itself to the colder portions of the heating chamber owing to the heat being lost through radiation.

In general, in high temperature furnace construction, there are two separate and distinct factors which must be considered in securing an effective wall.

The first of these is to provide a material having the ability to resist the action of high temperatures, sufficient mechanical strength, and possibly the property of resisting corrosive slags, gases, etc., without spalling or being eroded.

The second is to prevent the excessive loss of heat due to conduction from the interior of the furnace to the outside where it is lost. Rarely is a good refractory material a good insulator; usually it is necessary to back up the refractory lining with some material having a much lower heat-conducting capacity.

The requirements of the insulating backing for the more refractory lining are rather severe. An ideal material would have the following properties: It should have an extremely high insulating value and be sufficiently refractory so that no fusing or excessive shrinkage would take place in that portion which is in direct contact with the highly heated refractory wall.

It should not be decomposed and it should furthermore be of light weight, uneffected by moisture, of convenient form, readily applied by unskilled labor, and low in cost. It should be of such composition as not to react upon or attack either the refractory material or the metal shell of the container even in the presence of moisture. It should contain no free acid radicals, and should not be broken or caused to settle by vibration or heat. It should not have high expansion, and it should be sufficiently elastic to take up strains between the lining and the shell, produced by temperature changes.

Practical Consideration of Heat Transfer

In the practical consideration of heat transfer in our furnaces, conduction may be neglected in its relation to combustion since any conducting medium must receive its heat initially either by convection or radiation. Heating by convection will be done most easily and efficiently by raising some radiating medium to the greatest possible temperature.

This is the method in use in the usual form of furnace. The heat of convection of the products of combustion comes in contact with the furnace walls which rise in temperature and radiate their heat to the work. In the case of convection heating all the fuel should be burned and no free oxygen should be present in the flue gases, since to get the hottest products of combustion there must be complete combustion and a minimum weight of flue products.

To raise the radiant elements to the maximum temperature there must again be the condition of complete combustion of the fuel together with minimum flue products. There is another item to be considered in the case of radiant heat. The hotter the radiant element, the more rapidly can heat be transferred to a given object. For instance, a radiating element which is at 2,500 deg. Fahr. will transmit nearly twice as much heat per sq. ft. of its area in unit time as when it is at 2,000 deg. Fahr. Hence it becomes necessary to maintain the heating element at a maximum temperature during the absorption of heat from the element, and that can only be done by supplying a maximum amount of fuel to that element.

We can now summarize by saying that the best results in any heating operation will be obtained when the fuel is completely burned and the flue gas contains no free oxygen or carbon monoxide. It is also seen that when heating is to be done by radiation it is desirable to have a radiant element that can be controlled in temperature and varied nearly up to the theoretical flame temperature.

Given a furnace in which a maximum of radiant heat is produced and a minimum of excess air, it is clear that this furnace must be highly efficient.

By the use of an efficient insulating material the operating flame temperature will be brought near to the theoretical flame temperature and hence the amount of radiant energy materially increased.

Furnace Walls

In the design and construction of heat treating furnaces the conductivity of fire clay is of extreme importance. In oven furnaces where a large volume of heat is required, particular attention must be paid to the conductivity of the firebrick employed, so that the thickness of the wall may be determined to give the most economical working.

In the case of small furnaces which are used only during the day, and require to be heated up to a working temperature each morning, the time required for this preliminary heating up will to a great extent depend upon the thickness and conductivity of the wall. In such cases the quantity of brickwork should be a minimum; 2½" brick backed up by 2½" of a good insulating material such as Sil-O-Cel.

For large heat treating furnaces which are working continuously the thickness of the wall should not be less than 13½"; a 9" course of firebrick backed by a 4½" of Sil-O-Cel Insulating Brick.

In general, in high temperature wall construction, there are two separate and distinct factors which must be considered to produce an effective wall.

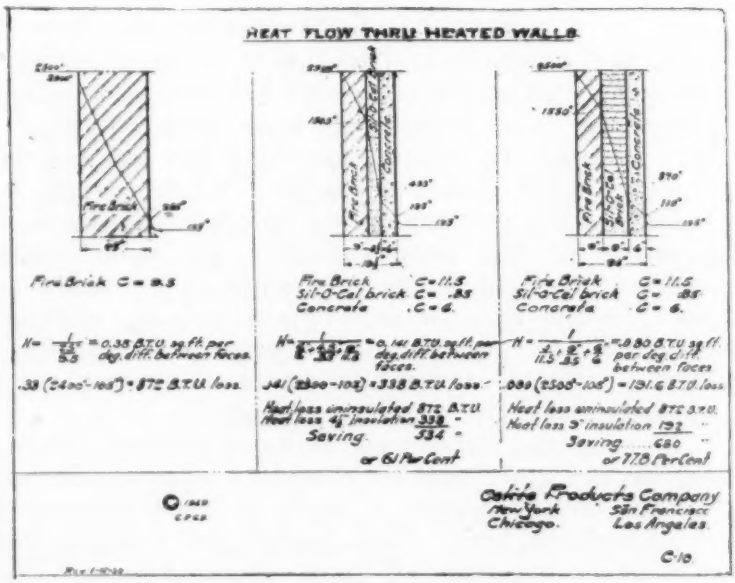


Figure 3

The first of these is to provide a material having the ability to resist the action of high temperatures, sufficient mechanical strength and, possibly, the property of resisting corrosive slags, gases, etc., without spalling or being eroded.

The second is to prevent the excessive loss of heat due to conduction from the interior of the wall to the outside where it is lost by radiation or conduction.

It is rare that a good refractory material is an insulator; usually it is necessary to augment or back up the refractory with some material having a much lower heat conducting capacity.

The three most important points in considering wall construction are:

1. A wall of sufficient thickness to withstand the strain.
2. A sufficient thickness to prevent excessive heat loss.
3. A wall sufficiently thin to conform to combustion chamber design.

Walls vary greatly in practice depending upon how much consideration has been given each of these points, in a thin wall the concentra-

tion of heat in a deep chamber is avoided but excessive wall radiation results. On the other hand in excessively thick walls the loss is reduced but higher cost and repair charges are entailed.

Proper Heating Furnace Insulation

That the firebrick lining of a furnace supplies sufficient insulation against heat losses is the common impression among furnace users, and but little attention is paid to the fact that the vicinity of a bank of furnaces is almost unbearable to one unused to the work on account of the excessive heat coming from the furnace.

The usual type of furnace usually consists of a firebrick lining and an outer casing of cast iron or sheet steel. In order to properly determine the amount of heat loss from the exposed plate it is necessary to know the temperature of the outer surface and the rate at which heat leaves the surface. Pyrometers may be used to determine the temperature of the furnace and the other data may be derived as usual. From a curve given by Charles R. Darling in "Engineering," London, the following approximate figures may be taken:

Temperature of Surface, deg. F.	B. T. U. escaping per sq. ft.
100	60
200	320
300	700
400	1240
500	1900
600	2680

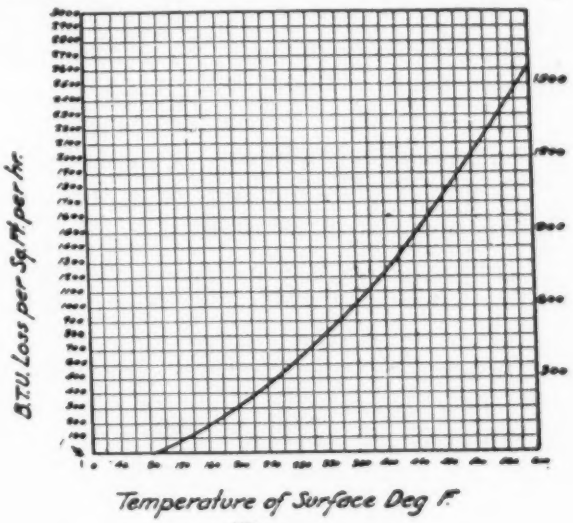


Figure 4

One reheating furnace for steel possessing an exposed surface of 430 sq. ft. (330 sq. ft. in the sides and 100 sq. ft. on the top) was observed for a week at normal working and readings of surface and internal temperatures were taken at stated intervals:

Location	Degrees F.
Interior	1450 to 1600
Exterior Plates average	300
Exterior Firebrick	390

The plate readings were taken from the sides, while the firebrick was used for a top and unprotected. Assuming the loss of heat from the firebrick to be at the same rate as from iron the total heat loss was $330 \times 700 + 100 \times 1100 = 341{,}000$ B. T. U.

Experiments with an electrically heated furnace on which readings were first taken with it unlagged, and then with lagging in place, showed the amount of saving which may be anticipated in such an insulation:

Internal tem. deg. F.	B. T. U. Escaping From Furnace Per Hour Without lagging	With lagging
400	450	150
800	1150	450
1200	2150	950
1600	3350	1650
1800	....	2050

The saving effected was more than 50 per cent over the entire range observed, greatly exceeding in value the cost of the additional insulation material and providing an additional reduction in maintenance cost.

Since the loss of heat through radiation is a function of the skin temperature, we can readily estimate from this the heat loss in B. T. U. Darling has given the heat loss from a heated metal wall for various temperatures, as shown graphically in Figure 1.

If closer figures for heat loss are desired, or temperature gradients throughout the various components the following formula is very useful:

$$H = \frac{1}{\frac{1}{K} \times \frac{d \times d_1 \times 1}{c \times c_1 \times K} \times (t_2 - t_3)}$$

Where

H—heat loss in B. T. U. per sq. ft. per hour.

t_2—temperature of the furnace gases.

t_3—room temperature.

K—a factor for heat emission.

d and d_1—thickness of furnace wall.

c and c_1—coefficients of conductivity of the various wall components, at the temperatures operated.

Conversely, to obtain the temperature drop or gradient, the reciprocal value is used for each material and divided into the heat loss in B. T. U. per hour. Temp. drop — $\frac{H}{\frac{K}{1}}$ between the inside gas temperature.

Temp. drop — $\frac{H}{\frac{c}{d}}$ for each component of the wall.

This gives the loss from a vertical wall. It has been found by actual experiment that the heat loss from a horizontal surface is approximately 22% greater than from a vertical surface.

Editor's Note: To be concluded in the November issue of the Transactions.

THE APPLICATION OF PYROMETERS TO THE HEAT TREATMENT OF STEEL

A. M. Redding*

Read before Buffalo Chapter

It is the purpose of this paper to take up the various types of pyrometer equipment, mentioning the advantages and the particular applications of the equipments; to discuss the considerations entering into the selection of pyrometer equipment for some of the usual heat treatments, and to describe a few typical first class installations. The phrase "type of equipment" as used here does not refer to the various manufacturers of pyrometers, but rather to the function of the equipment, i. e., indicating, recording, controlling, etc. The discussion will be limited to pyrometers of the thermocouple class wherein the measurement is made with either a galvanometer or a potentiometer.

The simplest type of pyrometer installation is the indicating system. It is the cheapest equipment, and likewise it gives the least information. The operator obtains only intermittent readings of the temperature, and it is not likely that he can keep in mind what has gone before, especially when he is concerned with several temperatures. He knows only the present temperature of each couple, which is only a part of the story.

The next step in the development of pyrometer equipment is to add to the indicating system a recorder. The indicator now is for the convenience of the furnace operator and is used by him when the reading it gives is a sufficient guide. For further information, or when concerned with rates or time intervals, he refers to the recorder. The record gives a check on the furnace operator's work and affords a ready reference in connection with subsequent physical tests of the product, or if the heat treatment proves to have been faulty.

The progression next leads to the central station system, that is, the recording and signalling system. The first central stations were manually operated, but soon the development of the instruments permitted the automatic central station.

If there is such a thing as an ideal pyrometer equipment, it is the automatic central station. The furnace operators are guided by signals given them by means of colored signal lamps and deviation meters mounted at the furnaces. The lamps and deviation meters are operated automatically by recording instruments in the control room, at the same time records are being made showing how closely the furnace operators follow the signals. The instruments being grouped together in the control room are in a safe place and can receive the best of care as one man only has charge of them.

If a furnace temperature varies outside the prescribed limits, the operator's attention is attracted by the flash of a signal lamp as soon as this change starts to take place. After his attention is gained he is guided further by the indications of the deviation meter which show him how many degrees the temperature is off and how fast and in what direction it is changing. This does away with the dangers that are present when a fireman reads several temperatures in succession from an indicator and, trying to remember them, goes to the various furnaces to make the adjustments. The chances are that he will forget or confuse the temperatures, and then rely on his eye to make the adjustment. With the signal lamps

*Leeds & Northrup Co.

and deflector the fireman has a continuous indication at each furnace. This indication is not merely in the form of a temperature reading in degrees, but really says to him "you are high 30°" or "you are 40° low" or "your temperature is O. K." The effect of this is the same as if the foreman stood with him all day telling him what the temperature was and the direction and amount of adjustment to make. The result is that the temperature is held just about as close to the desired value as is humanly possible. And this feat can be accomplished with a poorer class of labor. It does not take long to make an inexperienced man understand that the red light is showing him his furnace is too hot and the blue light, too cold, and that the pointer in the deviation meter is to be kept on zero.

These conditions just described are obtained by virtue of the instruments alone. They are due to the perfected design and the enlarged capabilities of the modern pyrometer. The central station idea itself also has its important advantages. Briefly the central station simplifies and renders more efficient the supervision and operation of the heat treatment. It is done in this way. The work is scheduled thru the various departments of the plant. The foreman of the heat treatment knows beforehand when certain work is coming to his department. He knows what that work is. He knows from his previous records exactly what treatment that work is to receive. From his own schedule he knows which furnaces will be free at that time to give the treatment; suppose there are four such furnaces, two of which will have just finished a treatment at 1500° F. and two at 1425° F. Suppose the new work in question is to be treated at 1500°. The foreman therefore schedules that work to go to the two furnaces which will be just finishing up at 1500° and the complete information in regard to this is noted, preferably on a chart in the central station. When this new work is delivered to the heat treatment department it is brought in and laid in front of the two furnaces which are to do the job as shown by the charter schedule. When a furnace is free it is charged with a lot of the new work. The furnace is already up to temperature or nearer to it than any of the others so that no needless time nor fuel is spent in bringing it up, as usually happens when the furnaces are selected at random. When the charge is ready to come out, this fact is signalled to the fireman. The responsibility for applying the correct temperature for the correct length of time has not been given to the fireman except insofar as he has had to follow the signal lamps, and this is watched by the foreman or assistant foreman on the floor. The operator in the central station is really the active brain of the heat treatment. He keeps the schedule revised and up-to-date. He knows what charge is in each furnace, when it went in, the treatment it is receiving, and when it shall come out. It is of course necessary that this operator be capable of carrying this responsibility and fulfilling these duties, and then only ordinary ability is required of the men at the furnaces.

To sum up, for the central station, the foreman has absolute and complete control of the entire situation. He knows from a glance at his schedule what is in each furnace, the treatment being given and the present stage of the treatment. New work coming in is scheduled so as to get efficiency in time and fuel. The furnaces are being controlled as closely as if the foreman were standing behind each man continually, and directing him.

The last type of equipment to be considered is the complete automatic control system. This is not yet in common use as it is a recent

development and in fact for some furnaces it is still impractical. The majority of present installations of automatic temperature control equipments are on electric furnaces or ovens. This is because of the simplicity and ease with which the heat supply can be controlled in electric furnaces. This is usually accomplished by means of automatic switches or rheostats and it is a very simple matter to control these from a potentiometer recorder. With other types of furnaces the application of automatic control is being held up by the difficulty of providing a mechanism which can be operated by the recorder, and which in turn will properly control the supply of heat to the furnace. Nevertheless some of these installations have been made and are giving satisfaction depending upon the efficiency and proper operation of the valve adjusting mechanism. In one plant in particular, two circular continuous electric furnaces and two circular continuous oil fired furnaces are used for hardening and annealing automobile spring leaves. Automatic control was installed on the electric furnaces and gave very satisfactory results. The management then wished to install automatic control on the oil furnaces to obtain the same benefits. Accordingly one of the men designed and built a small motor operated mechanism to regulate an oil burner, the motor being controlled by a potentiometer recorder. This apparatus was installed on one burner of a four burner furnace, and, after a little experimenting to determine the proper setting of the other three valves, it was found that by leaving the three burners permanently set and controlling the fourth automatically, the furnace temperature was held within plus or minus 10° F.

When it comes to making the selection of pyrometer equipment for a particular installation, we are confronted with a problem which unfortunately in many cases is treated too lightly. We install pyrometers not to gratify any whim, not for decorative purposes, not just to spend money, but to enable us to improve operations and obtain results which otherwise are beyond reach. A pyrometer equipment usually means a fairly large first cost. This money is not being thrown away but is being invested to pay dividends. These dividends will not be as large as they might if the pyrometer equipment has not been selected as being best suited to that work. When making the selection the problem is not merely what make of instrument to secure, but also what will be the function of that equipment.

There must be taken into consideration such factors as the following: complete cycle of furnace treatment was not a success, as the heat had not penetrated to the center of the forging, although the work had been soaked for a time which previously had been considered to be sufficient. However, the inspectors would not pass the treatment. A test run was made with thermocouples imbedded at different depths in holes drilled in the forging. One couple was at the very center of the forging, another on the surface and others spaced in between. These couples as well as couples in the furnace gases were recorded on a multiple point recorder. The record showed that when holding their usual furnace temperature it required over twice the time they had been allowing for the center of the forging to come up to the temperature, and here the time may be measured in days rather than hours. Succeeding treatments utilizing the information thus gained were successful.

The indicating and recording equipment is probably the type which will best meet the needs in this kind of work. The use of the signal lamp system is prevented by the fact that the number of thermocouples used

in one furnace may be as great as twenty, and the cost of the signalling equipment would be prohibitive.

In the heat treatment of smaller work such as axles, springs, crank shafts, etc., the principles are very nearly the same as in the work just taken up, but all is on a smaller scale. For either the hardening or annealing of this kind of work the best system, if it can be used, is the signal lamp and deflector system, or in other words the automatic central station. The advantages of this type of instrument are obtained with an equipment for only one furnace as well as 50 furnaces. The advantages of the central station idea, i. e., the facilities for scheduling the work and securing increased efficiency in the operation of the whole department, are more apparent, the larger the installation.

Should it happen that one of these treatments is given in an electric furnace, there is an automatic equipment to control the treatment which gives very interesting results. The pyrometer is a one point two temperature controller connected to two thermocouples, both in the same furnace. One couple has its hot end in immediate contact with, or buried in, the work, and is called the contact couple. The other is located in the atmosphere of the furnace preferably near the heat source. The control discs on the potentiometer recorder are so set that as long as the contact couple is below a predetermined temperature the furnace couple tends to hold the furnace at a high temperature to force heat into the charge, but after the contact couple has reached the desired temperature, the controller automatically throws over and tends to hold the furnace couple at a lower temperature, which is usually set at a value just sufficient to supply the radiation losses, thus holding the charge constant.

One application of this was in gun treatment work, the contact couple was in immediate contact with the gun in a G. E. furnace and the furnace couple was located near the resistor winding. The controller was set to hold a comparatively high temperature, about 1800° F., and this temperature was maintained until the contact couple showed that the surface of the work had reached, say 1450° F., when the control shifted and the temperature of the furnace couple was gradually and automatically reduced to a temperature just above the finishing temperature of the work, and held until the work was thoroughly "soaked." When the control first throws over to the lower temperature, the interior of the charge will absorb heat from the surface sufficient to cause a rapid fall of the surface temperature below 1450° F., when the relays will operate in the reverse order and the original connections will be restored, which will again raise the temperature to 1450° F. and again throw over the control. This cycle of operations will continue until the interior has ceased to draw heat from the surface of the charge, or in other words until the charge is heated thru, and thereafter the control will remain thrown over to the low temperature setting which is only slightly above the finishing temperature, and just enough to supply the radiation losses of the furnace. Thus the charge is heated at the maximum rate without danger of being overheated.

The pyrometer equipment for carbonizing heats could also be of the automatic signalling or central station type. The indicator and multiple point recorder equipment would give good service but it is rather second choice. For carbonizing the temperature is held constant for a considerable time, and therein the automatic signalling excels. The temperature

that is to be kept constant, is the temperature of the work itself, within the box. This can be best accomplished by controlling the temperature of the gases in the furnace, for there is a lag between these two temperatures and if the gases are controlled within close limits the work will be between still closer limits. It is necessary to know the lag, or the relation between the gases and the work, particularly during the heating up stage so that the correct time will be allowed to get the desired depth of penetration in the work. This temperature relation can be found by experiment, by placing one or more bare couples in contact with the work and recording their temperatures with that of the gases.

Box or pot annealing affords a very interesting application of pyrometers. The requirements are somewhat similar to those in carbonizing work, in that the temperature with which the operator is concerned, the duration of which must be for sufficient time, is the temperature of the work within the box or pot; while the temperature most readily measured and the one which is directly controlled is that of the furnace gases. It is essential for a successful treatment that the temperature be held sufficiently long for the work to become uniform throughout its mass, while on the other hand, holding the temperature for more than this time is simply a waste of time and fuel.

Probably the most successful equipment for this work, of which the writer knows, consists of a two temperature recorder for each furnace. One of the temperatures recorded is that of the furnace gases; the other is the temperature inside the pot or box, if there is only one box per furnace, or inside the most representative box if there are several boxes in a furnace. Both temperatures are shown on the one record sheet. As the furnace is heating up the fireman holds the temperature of the gases sufficiently above the temperature of the work to secure a good rate of heating. As the finishing temperature of the work is approached, the gas temperature can be cut down until it is just enough above the work to supply radiation losses and hold the work steady. Even though the overshooting of the temperature on heating up would not spoil the treatment, still it is a waste of fuel, and so should be avoided. Having a record of the two temperatures, the fireman can observe both the "cause" and the "effect." He can anticipate by several minutes, changes in the rate of heating, or deviations from the steady temperature, and take action to successfully make or prevent these changes as the case may be.

Another equipment which has been applied successfully to this kind of work is the indicator and multiple point recorder equipment, reading the temperatures of the furnace gases only. However, in each case it has been necessary to make experimental runs with some thermocouples in actual contact with the work, to determine the relation between the work and the gas temperatures. This method does not give as close temperature control as the two temperature recorder method, but then it is claimed by some, and with reason, that a close control is not a requisite for success in this treatment. On the other hand a close control will surely not detract from the success of the treatment, and it will give a better fuel economy.

When we consider such work as the hardening of tools and dies, we are tackling a very large and difficult problem. Hardening is being done by a number of methods and with widely differing results. All types of pyrometer equipment are being used. Broadly speaking, it can be said that the signal lamp and deflector system should be given first choice

with the indicator and multiple point recorder next. There is a recent very interesting development in the field of hardening tools, dies, gears, etc., which should be taken up at least briefly because of its very marked advance in method and results. That is the Hump Method.

In this method the outward manifestation of the changes in internal structure which take place when steel is heated past the so-called critical or transformation point is employed to indicate when the work should be withdrawn from the furnace. A vertical electric furnace is used and its construction and operation are such that all parts of the charge are at a uniform temperature and heat up uniformly. It is found that the rate of temperature increase has a marked influence upon the properties exhibited by the steel after quenching. The rate of heating is easily controlled in an electric furnace. All parts of the charge pass through the critical point at the same time, and thus avoid stresses and distortions which would follow from unequal expansion or contraction if different parts of the work passed through the critical point at different times. The passage thru the critical point is indicated by a hump in the curve that is being drawn on the potentiometer recorder chart. Before quenching it is necessary to heat the work a certain distance above the critical point, this distance depending upon the mass and shape of the steel, the quenching medium employed, and the qualities desired. The exact further heating to be allowed after passing thru the critical point is learned by experience or trial, but once known, all uncertainty as to the result is practically eliminated, and results can be repeated. This method eliminates all errors due to non-uniform temperature in the furnace, failure of the work to reach the furnace temperature, and incorrect information regarding the location of the critical point. The Hump Treatment equipment itself also has these advantages: the work is protected against fresh supplies of oxygen, thus avoiding scaling or decarbonization; electric furnaces are long lived and have low upkeep charges; working conditions in the heat treating room are improved, due to lower temperatures and absence of smoke and noise of burners; the hardening and drawing furnaces are cleanly in operation and can be installed in comparatively small space in the machine shop; and others of lesser importance.

The general need for pyrometers in heat treatment is known to be present and, what is more important, that need is receiving wider recognition. This is to be expected for the advantages of the proper pyrometer equipment have been demonstrated over and over again. The recognition of the need for pyrometers was given a decided impetus by the war and the conditions under which we were working at that time. There was a demand for steel in all forms for ordnance and other purposes. In most cases the steel had to meet very strict and severe specifications because of the purpose to which it was to be put. And then it was found that these specifications could not be met, sometimes not at all, other times at least without any degree of certainty and regularity without the use of pyrometers.

And still it is very interesting to observe the widely differing views held by men who have to do with pyrometers, in regard to the importance of these instruments. Some of the hardeners and others of the old school will glance contemptuously in the general direction of the pyrometer, make a few terse remarks concerning pyrometers and the man who will use one, and go on with their work judging temperatures by their eye and using other approximate guides which their experience has taught

them. Another man claims enthusiastically that a pyrometer should be the steel treater's Bible, the information it gives accepted in blind faith. These are the extreme views, and yet there are times when each one is just about right. There are some jobs on which a pyrometer is of very little, if any, help. There are other cases where the pyrometer tells the complete story and enables a man to turn out better and more uniform work than he could possibly do alone. The proper view to adopt is one that is somewhere between these two. You surely must have faith and confidence in your pyrometers else they are of no value to you. This must not, however, be a blind faith; but must be a faith born of knowledge and understanding of the instruments and of the theories and principles underlying them; and a faith that is strengthened by careful supervision and checking of the equipment. Get to know your equipment and understand it. Get to know how much important information the equipment will give you, how much you may rely upon it and also know its limitations. Then use the equipment to the limit, get as much help from it as you can, but do not try to exceed that. Do not thoughtlessly expect your pyrometer equipment to do the impossible.

STEEL AND THE FORGE SHOP MAN

F. L. Moister*

"Mysterious Failures of Steel" were of common occurrence twenty years ago. The investigation of steel has advanced to such a stage that it is no longer classed with the "Mysteries." Its broader use, knowledge of how to impart the desired qualities by heat treatment, and the changes in structure which take place under varying conditions of work and temerature, were arrived at by comparison of findings and interchange of ideas and methods. It was by close study and careful examination in the shop and laboratory, that so much is known about this most complex of all metals.

The laboratory investigation is extremely important, but the commercial application of the findings of such investigations is generally in the hands of the Forge Shop Man who is supposed to follow instructions without question, but who seldom knows what he is aiming at or what he has accomplished. Hence the suggestion in the following that he be enlightened enough to perform his part intelligently and to know what properties his work is intended to impart to the steel.

Why is the heat treatment of steel generally described in such highly technical terms that the forge shop man, who performs the actual operations, has but a vague idea of the meaning? Does the metallurgist think it such an intricate problem, known only to the laboratory investigator, that the shop man cannot grasp it?

One argument has been advanced that if the shop man knows too much about the science, for it is a science, he will not follow instructions but work according to his own ideas. This is preposterous for should such condition arise it would be an easy matter to put your hand on a man scheduled for immediate discharge.

Another weak argument is, if the shop man be kept too well posted on the results of his work, there would be many embryo metallurgists in the shops, the profession soon become common and overcrowded.

The forge shop man need not know the exact chemical composition

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of the steel as this is within the province of the metallurgist, but he should know that the aim of heat treatment is to change the grain of the steel to such a degree of fineness and toughness as will insure the results being equal to requirements, that the composition is such that if he carries out the specified treatment the results **must** be within stated limits, that if the results are not what is desired it is evidence that he did not follow instructions in every particular.

The exact treatment should be determined before instructing the shop and not changed each time the tests show failure. This is very important, and gives the shop man confidence in the metallurgist, for confidence and perfect co-operation are absolutely essential to success.

It is not necessary to talk to the shop man about eutectics, micrograin, macrograin, ferrite, pearlite, sorbite, etc., etc., but use the word grain, with qualifying adjectives if advisable. Steel is of granular structure, coarse grain, that is a grain that is coarse to the eye means inferior physical qualities, while fine grain means superior qualities.

A carpenter knows how to work various woods to best advantage although no two are alike, but he can do nothing to change the physical characteristics of the wood.

A machinist is given a piece of steel and a dimensioned sketch or drawing to which it must be finished. He has no control over the quality of the metal. His work is mechanical, setting the piece on the machine, selecting the proper tool, controlling the cut and measuring accurately so that when the piece leaves his hands it will be of correct dimensions and finish. He sees the completed piece and knows if his work has been good or bad.

Steel is the most mobile and complex of all metals, capable of the greatest structural changes, yet the forge shop man remains in ignorance of its characteristics and has but a vague idea of what his work is doing to the structure of the metal. He is given a piece of steel about which he knows nothing to heat and forge into a definite shape, not appreciating that he is changing its structure as well as its shape or that a great deal depends on careful heating and skillful forging in order to produce a piece in which the grain is in the best possible condition to withstand the stresses put on it in service, or for subsequent heat treatment. His thought is to heat and forge it as quickly as possible with hammer work reduced to a minimum. To arrive at this, which to him is the very acme of achievement, the steel is heated too hot and forged too quickly to obtain the fine grain desired.

This condition exists in most forge shops and it should be corrected by a series of instructions with illustrations to the forge men so that they know what they are doing to the steel other than to bring it to the desired shape. The points on which he should be enlightened are:

1. The principle methods of making steel, Bessemer, Open Hearth, Crucible.
2. The effect of the common chemical components on the physical properties of the steel, carbon, sulphur, phosphorus, manganese and silicon.
3. Defects found in forging billets and blooms,—piping, sponginess, seams, splits and torn edges, how to detect them, what causes them, and their effect on the forgings.
4. The effect of heating and forging at various temperatures.
5. The effect on the grain of the steel of normal cooling and of

delayed cooling from last forging temperature. In many shops forgings are piled from the hammer and cooling delayed. This is very injurious, particularly in large forgings, and complicates subsequent heat treatment.

6. The refining effect on the grain of annealing. That delayed cooling is not annealing, but that heating after the forging is cooled, followed by normal cooling is annealing.

7. The effect of quenching at varying temperatures.

8. The softening and toughening effect of the draw.

9. What is meant by tensile or ultimate strength, elastic limit, per cent of elongation, per cent of reduction of area and what they indicate in the physical properties of the steel. Tensile test pieces should be pulled in the presence of the forge man.

This list might be extended indefinitely but many other points could be brought out without enlarging it so as to make the instructions comprehensive, practical and within the grasp of the forge shop man.

Any honest workman wants to turn out good work. Any good forge man wants to turn out good forgings. How much better it would be to enlighten him in the fundamentals of metallurgy so that he knows whether his work be for good steel or not. He knows many things about how to work steel into shape to best advantage which the metallurgist does not know. If his mechanical skill was supplemented by a knowledge of the structure of steel, he would turn out better work, the metallurgists' problem be simplified, and the ultimate result would be toward greater efficiency and better components in our structures.

PRODUCER GAS FOR HEAT TREATING

Geo. H. Trout*

Paper read before the American Society for Steel Treating Convention at Philadelphia, Septe ber, 1920.

It is not difficult to recall the days when hand fired coal furnaces were used for all kinds of furnace work. The labor attached to doing work by this method was excessive and as wages were increased, fuel oil became a very convenient medium of obtaining heat. It is surprising, though, that more attention was not paid to the application and adaptability of fuel oil to furnace work. This was possibly due to the fact that fuel oil became very cheap and because of its high flame temperature, it was comparatively easy to obtain almost any desired temperature without much effort.

As fuel oil increased in price, some study was made of burners, but only recently has furnace design been given any consideration from the point of greater economy and adaptability to the work in question.

For low temperature work the general practice has been to utilize fuel oil by any one of the three following methods:

First: With an excess of oil with its attendant incomplete combustion and smoky furnace.

Second: With a heavy air excess, so that the flame temperature of the oil under complete combustion could be held down.

Third: In the Muffle furnace.

Each of these methods has been found to be inefficient.

Fuel oil is now not only high priced but the supply is inadequate, and the evidence clearly indicates that both these conditions probably will be permanent. That price is not the sole consideration in this day

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of striving for a better product, is evidenced by the fact that some concerns are now operating electric heat treating furnaces even at a greater cost in the endeavor to obtain better results.

Another fuel available for heat treating is producer gas.

There are two kinds of producer gas, "Hot" or "Raw" gas and cold, clean gas.

Producer gas from bituminous coal in its raw state carries large quantities of tar vapor and lamp black. When the gas is used hot, the greater part of the tar is not condensed, but remains in the gas. It is usual in this process to endeavor to keep the temperatures of the gas above the condensing point of the tar in transporting it from the producer to the furnace. The gas mains for delivery of hot or raw gas must be large in diameter and lined with fire brick. The accumulated lamp black and heavy pitch must be burned out of these mains at least once every week. For this reason, hot gas has a very limited application and is most commonly used only in connection with large furnaces, such as open hearths, soaking pits, glass melting tanks, brick kilns, lime kilns, etc., where the producer can be located close to the furnace. It is impracticable to distribute this raw gas thru any extensive gas distributing system.

Clean, cold producer gas is made up of the same constituents as raw gas, except that it is subjected to a cleaning process which reduces the temperature to about that of the surrounding atmosphere and at the same time, tar and lamp black are removed.

Clean producer gas for heat treating has many advantages, some of which are:

First: It may be made from anthracite, coke, charcoal, bituminous coal and lignite, our most abundant fuels.

Second: When cleaned it may be distributed in the same manner as natural or city gas.

Third: It makes possible the centralization of the coal and ash handling equipment.

Fourth: Within the ordinary range of oxidizing or reducing furnace conditions clean producer gas burns with a smokeless flame.

Fifth: It has proven successful in many applications to furnace work, not only from the standpoint of economies, but from the standpoint of better product.

Sixth: No method of furnace heating is so easy to control when properly installed as clean producer gas.

A clean gas plant can be located at any point on the owner's premises that is convenient for the handling of coal and ash and the gas may be distributed thru common steel pipe and fittings to any department of the works where fuel is required in just the same manner as natural gas or city gas is distributed.

The field for clean producer gas seems at this time to be unlimited, as may be noted by the fact that it has been used in the baking of breakfast foods, roasting coffee and other baking operations in the food industry, for core oven and mould drying in the foundry, for japanning, lead melting, soldering, brazing, heat treating, forging, box pile welding, rolling mills, etc., in the metal industry, for glass melting and glass annealing in the glass industry and for many applications in the chemical industry. Clean gas is also being used to mix with natural gas for distribution to domestic and industrial consumers in one of our largest cities.

Owing to the fact that many early installations of clean producer

gas were not equipped with a meter, it has been difficult to obtain exact figures, but the following comparison indicates the possibilities of producer gas:

One of our large automobile manufacturers has now installed clean producer gas equipment having a combined capacity of 50,000,000 cubic feet per 24 hours, with additional equipment now in the course of installation that will double this capacity. At this plant clean gas has proven an ideal fuel for all types of heat treating furnaces. It burns with a clear blue flame, giving a furnace atmosphere that is transparent, and even when working with a reducing flame, it does not smoke. The furnace rooms are much cleaner than where oil is used. It is uniform in quality and pressure and anyone familiar with the use of gas of any kind for furnace work realizes the value of uniformity of both quality and pressure for keeping temperatures and furnace atmospheres constant. The producer gas flame is soft and penetrating, whereas the oil flame is harsh and cutting. This feature has increased the life of the furnace linings and reduced the cost of furnace repairs. Packing boxes last longer, reducing the cost for renewals.

It is claimed by one foreman of the heat treat department where producer gas was used to replace oil that with gas he increased the output of his furnaces by one-third and handled his output with two-thirds the labor. Another has claimed and sent in records showing double the output on an annealing furnace with gas compared with oil. A careful study of gas application may give such a result, if the oil installation was poorly made, and there are many such installations. In no case is it necessary with producer gas to countenance a decrease in output and most of the data secured insures an increase.

The following data is taken from a comparative test report made by the engineers of an automobile manufacturer covering the use of producer gas and fuel oil in a heat treating furnace.

FURNACE—Furnaces of the underfired type, size of hearth 66″ x 56″ x 16″ high to crown of arch, 9″ walls, combustion chamber underneath divided in middle by 9″ wall with two burners in each chamber located at opposite ends. No change made in furnace for making comparative test except to change the burner. Standard make of burner used for oil test. "Self induction burner" designed for producer gas was used in the gas test with broken firebrick placed in front of each burner.

OIL USED—The western variety of fuel oil containing 18,000 B. T. U. per pound or 140,045 B. T. U. per gallon under a pressure of 40 pounds per square inch. Air for oil burner at 1 pound pressure. Oil temperature at burner 67° Fahr., air temperature at burner 79° Fahr.

GAS USED—Clean, cold producer gas temperature at burner 109° F., B. T. U. value 165 per cu. ft. Pressure at burner 1.9 inches mercury.

PREPARATION FOR TEST—Careful and complete precautions were taken for measuring the oil and metering the gas. Six consecutive runs were made to assure accuracy with a difference of only .6% between any two runs. The barometric pressure, temperature, density and calorific values were observed and used in checking results.

MATERIAL TREATED—Steel gear blanks in a flat ring weight 8 pounds each; thickest part of metal 1″. Furnace charge consisted of 131 pieces as above with a total weight of 1,048 pounds. Temperature of material when charged 60° F.

THE TEST—In each test for gas and oil the cycle started by putting the metal in the furnace and closing the door. The temperature of the

furnace was then brought up to 1560° Fahr., which required about 35 minutes. This temperature was then held constant for one hour, making the total elapsed time one hour and thirty-five minutes. The charge was then raked out. The average time to bring the batch up to heat using oil was 39 minutes; when using gas was 35½ minutes.

RESULTS OF TEST USING FUEL OIL

To bring up to heat.....	9.3333 gal. or	1,307,087 B. T. U.
To hold temperature.....	7.1692 gal. or	1,004,110 B. T. U.
Total .....16.5025 gal. or		2,411,197 B. T. U.

RESULTS WITH GAS

To bring to heat 5,005 cu. ft. at 165 B. T. U. or		825,825 B. T. U.
To hold temp... 3,390 cu. ft. at 165 B. T. U. or		559,350 B. T. U.
Total ..... 8,395 cu. ft. at 165 B. T. U. or		1,385,175 B. T. U.

The heat absorbed by the steel in raising it from 60° Fahr. to 1560° Fahr. would be approximately 258.4 B. T. U. per pound using .17226 for their specific heat. Considering only the heat input into the furnace during the "bringing to heat" period it required an input of 1,247 B. T. U. of oil per pound of metal. Under the same conditions using gas the heat input to the furnace was 788 B. T. U. per pound of metal.

In a subsequent run made with 1,360 pounds of the same stock and using gas it required a heat input of 670 B. T. U. per pound of metal.

It is very interesting to note that the total B. T. U. required for the one hour and 35 minutes was less when using gas than when using oil. If we assume that the coal used in the producer contains 13,000 B. T. U. per pound and a producer efficiency of 70% it required 152 pounds of coal fired to the producer to obtain this result with producer gas. Another comparison is that 9.2 pounds of coal fired to the producer did the work of one gallon of fuel oil fired to the furnace or seven pounds of steel were heated per pound of coal.

Another test was made on a battery of twelve large continuous carbonizing furnaces of the inclined type set on a platform 4′ above the floor and had three race-ways for the carbonizing pots.

The material treated consisted of six-steel ring-type gears about 9″ in diameter packed in a round container having a central tube. This container completely assembled for the furnace weighed about 119 pounds. Each gear weighed about 6 pounds. There were over fifty of these containers in the furnace at one time. The temperature of this furnace was 1750° Fahr. The material was held to heat in this furnace for five hours and forty minutes. Pressure air and gas at about 21″ of water were used without any pre-heat. The B. T. U. value of the gas was 177 on the three days on which these tests were made. In the process of carbonizing these steel gears three pots were pulled every twenty minutes and three pots added with a pushing device at the top of the incline. The fuel oil used per hour on these furnaces was 184 gallons. The cold, clean producer gas used per hour under same condition was 131,000 cu. ft. The temperature of the oil going into the furnace was 68° Fahr. and the gas tempera-

ture was 102° Fahr. The fuel cost per piece on producer gas was a trifle over 1c and as near as could be arrived at the cost per piece using fuel oil was about 2.1c.

Observations were taken on the deterioration of the combustion chambers under the two fuels. The oil gave a localized heat and the flame contact under pressure gradually broke down the supporting fire brick underneath the slide, necessitating rebuilding within six months. The deterioration with the gas was not 15% of that of oil.

When carbonizing with oil 184 gallons were used per hour. With producer gas, 2,500 pounds of coal per hour fired to the producer did the same work. In this instance 13½ pounds of coal was found to do the work of one gallon of oil. It is evident that the carbonizing furnace was better adapted to the use of oil fuel than the heat treat furnace referred to in the previous test. This is accounted for by the fact that the combustion chamber under the carbonizing furnace is large, allowing for more complete combustion of the fuel oil before passing into the heating chamber.

Three essential features stand out prominently in these tests. First, the use of gas showed considerable economy over fuel oil. Second, there was a great improvement in conditions around the furnace when gas was used. Third, producer gas should not be compared with oil on a B. T. U. basis only, but in connection with the furnace design and nature of the work to be done.

Clean producer gas can usually be applied to any ordinary heat treating furnace by simply changing the burner. Mechanical types of burners will show added economy and the use of recuperators or regenerators will also effect a substantial saving in fuel, but these while desirable are not necessary for operating success.

Clean producer gas as an industrial fuel is becoming more popular every year. It is now being used by industrial leaders such as the Crucible Steel Co., the Halcomb Steel Co., the Aluminum Co. of America, the Hazel-Atlas Glass Co., Ford Motor Co., A. O. Smith Co., Jeffrey Mfg. Co., Delco Division of General Motors Co., Robbins & Myers Co. and many others in similar lines of industry. These few are mentioned to illustrate the broad application of this unparalleled method of using coal as an industrial fuel.

The generation of large volumes of clean producer gas or the central fuel conditioning plants for large industrial applications was made possible by the development of a new and simple process of cleaning the gas. By this method as now improved it is possible to remove 99½% of the tar from the gas. Time and experience has thoroly demonstrated this system as an efficient, dependable and economical source of fuel supply. The objectionable features which are inherent in any extensive new system have been eliminated so that today a very satisfactory commercial installation can be made where exacting conditions and economy are desired.

In closing it may be well to state that too little time has been given from a metallurgical standpoint to the actual effect of different fuels on various steel products, and little if any thought given to the most efficient methods of applying fuel to furnace work. We must spend more time and study on these problems and surely one solution is clean producer gas.

DENDRITIC STEEL

H. G. Carter*

A Paper Presented Before the Milwaukee Chapter

Dendrites are many times called by other names, such as, "pine trees" and "cores." Possibly you are more familiar with the terms "pine tree structure" and "cored structure" than with "dendritic structure." However, in crystallography, the structure is indicated by the term "dendrite," for this reason I shall use the crystallographic term "dendrite."

Fig. 1 shows the iron-carbon diagram; let us consider the manner in which steel solidifies. Above the line AG, the liquidus, the steel is entirely liquid; below the line AFG, the solidus, the steel is entirely solid; in between these lines the steel is partly liquid and partly solid. It is here that we are interested, for it is during the solidification period that dendrites form.

Let us see how the phase rule applies to steel. The phase rule may be expressed by the formula

$$F = C - P + 2$$

where F is the number of degrees of freedom, C is the number of components, P is the number of phases and the 2 represents temperature and pressure. If we consider that the pressure is atmospheric, it will remain practically constant, and therefore, may be neglected, making the formula

$$F = C - P + 1.$$

The degrees of freedom are temperature and concentration, as we have considered the pressure constant or fixed. In steel the number of components are two, iron and carbon (neglecting the small amounts of Mn, Si, S, P, also the special alloying elements put in the alloy steels). The phases are liquid iron, liquid Fe_3C, solid solution of Fe_3C in gamma iron (austenite), solid beta iron, solid alpha iron, solid solution of Fe_3C in beta iron (martensite), solid cementite, and possibly others.

Above the liquidus there is only one phase, liquid, hence the system is bivariant, and can change over a wide range of temperature and concentration of Fe_3C in iron and still be liquid. I have neglected the gas phase because the vapor pressure of liquid steel in the range of temperatures in which we are interested is very small.

Below the solidus and above the critical range there is only one phase, solid solution of Fe_3C in gamma iron. The system is therefore bivariant similar to that above the liquidus.

Between the liquidus and the solidus we have two phases, liquid and solid, therefore the system becomes univariant. The variable being temperature; if we fix the temperature everything is fixed.

We may express the phase rule a little differently by the formula, potential energy of the liquid = the potential energy of the solid + heat lost or gained. By heat lost or gained, or in scientific terms, the latent heat of fusion, I mean the heat that is given off on cooling or absorbed on heating. A change in temperature means that there must be a change in the potential energies, that is, a change in the relative amounts of liquid and solid phases.

To illustrate, if we add heat, some of the solid melts; if we remove

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heat, some of the liquid freezes. Therefore with each slight drop in temperature crystals are deposited until all of the liquid has frozen. However during the solidification period the rate of cooling is much slower than while the temperature is above the liquidus or below the solidus, due to the liberation of heat with the change of state.

Refer now to the diagram, Fig. 1. When the metal cools to temperature indicated by A, pure iron starts to freeze at various places along the outer surface of the casting. As the octahedron is the crystallographic form in which iron and steel solidify, the pure iron freezes along the three axes of the octahedron.

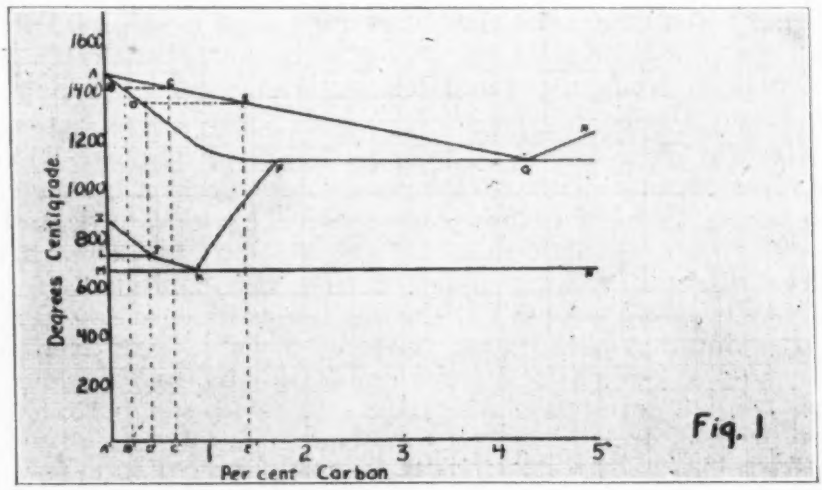

Fig. 1. Iron-Carbon diagram.

Now let us suppose the temperature has fallen very slightly, say to B on the diagram. An alloy A′B′ Fe_3C and iron freezes as a layer on the first octahedron, and adds another octahedron to the axes of the first (Fig. 2A). This layer is only slightly poorer in iron than the first crystal and contains a small amount of Fe_3C, the mother liquid becoming proportionately richer in the carbide and poorer in iron, and has a composition represented at C or A′C′, Fe_3C and iron.

Now let us suppose the temperature has fallen a little bit more, say to D on the diagram. An alloy A′D′ Fe_3C and iron freezes as a second layer on the first layer and adds another octahedron to the axes of the previous crystals (Fig. 2). This layer is poorer in iron and richer in carbide than the previous layer, and the mother liquid becomes correspondingly richer in carbide and poorer in iron.

At each slight drop in temperature, a layer deposits on the already frozen crystals, each successive layer becoming poorer and poorer in iron.

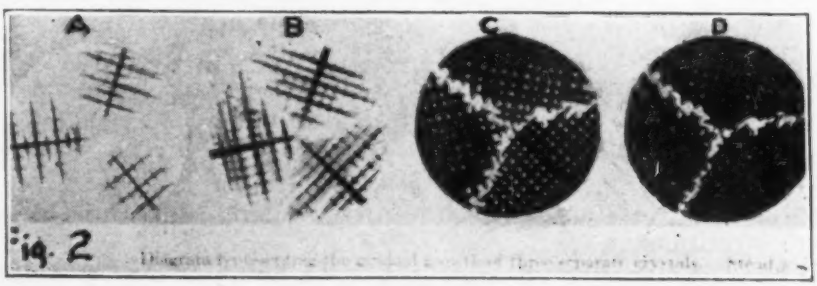

Fig. 2 Diagram showing manner steel freezes.

and richer and richer in carbide until the entire mass has frozen; at the same time the mother liquid becomes richer and richer in carbide and consequently poorer and poorer in iron.

The dendrite grows faster toward the center of the casting than sidewise, because the liquid at the center of the casting does not become exhausted of iron as fast as the liquid on the sides of the dendrites. Finally the dendrites become so large that their branches interlock, trapping any gas, slag, or other foreign material, and preventing their escape to the riser. If the metal was "wild" when poured, porous and dirty steel results.

The liquid last to freeze is rich in carbide, and if sulphur, phosphorus, and dirt is high it will be all, or nearly all, contained in this last metal to freeze, which is between the dendrites, or land locked by their branches (Figs. 3, 4, 7 and 9).

Just after the last drop has frozen, the dendrites will have a very heterogeneous structure with a chemical composition varying from pure iron at the center to high carbon exteriors. This non-uniformity results in a casting having very little ductility or power to resist repeated shock.

The crystallization taking place during the solidification period is called "primary crystallization." If during the process of solidification, the molten mother liquid is withdrawn, "isolated crystals" are exposed.

The question at once arises, since dendrites always form during solidification, why do we not always find them? The answer is that the carbon or the carbide, will diffuse in the solid state just below the solidus, if given sufficient time while the steel is hot enough; the rate of diffusion decreases very rapidly with a small drop in temperature.

Take the case of large castings such as ingots for example. The cooling of so large a mass is very slow, therefore both time and temperature are allowed for the diffusion to complete itself, in which case the interlocking branches of the dendrites form the grain boundaries of the austenitic grain. This period of diffusion is called "granulation." It really continues until the critical range is reached, at which time the steel is made up of a number of grains, each grain is built up of small octahedra, each having its own orientation. This structure we call austenite.

Such impurities as sulphur or sulphides, phosphorus, slags, etc., do not diffuse or at best extremely slowly, so that if the steel is not clean, these impurities are found segregated at the grain boundaries and are a source of trouble.

Austenite that has had its structure equalized (Fig. 5) responds to heat treatment readily (Fig. 6), but if its structure has not been equalized, it will not so respond.

Many of the readers doubtless have had tests fall down repeatedly even after several annealings and have wondered why, since as far as they knew the steel was satisfactory.

As Metallographist I have been at many of the foundries making small castings and have observed that in many cases the castings have been stripped very hot, not only red hot, but I have seen them practically white hot. The reason for this early stripping, so far as I could observe, was to get the castings out of the way so that the floor space could be cleaned up and the next set of molds gotten ready; in other words, trying to speed up production.

Our office has inspected castings which have failed badly in the ductility requirements; several reannealings seemed to make little or no

improvement and the castings were finally rejected (Table 1). On looking at the test bars under the microscope, beautiful examples of dendrites were found, even in the test bars which had received several annealings (Figs. 3 and 4). Some of the castings which behaved this way were known to have been stripped while very hot; the others were therefore presumed to have been treated in the same manner. We have found no such formation in test bars taken from castings known to have been cooled slowly, such as from large castings (Figs. 5 and 6), with the exception of castings which were very dirty. In these, remnants of the dendritic formation were seen, as shown by the segregated dirt, such as slag and sulphides. These impurities were found highly segregated in the grain boundaries, which I have just shown are the metal surrounding the dendrites just before the freezing is complete, and contain the trapped impurities.

The connection between early stripping and poor tests caused by dendrites finally dawned upon us, and it was decided to run an experiment to prove it. Accordingly we asked one of the foundries (at whose plant we were inspecting at the time) if they would help us run the experiment, which they did.

Two sets of test bars were cast in two separate flasks placed beside each other, and one was poured immediately after the other from the same metal. One set was shaken out of the sand as soon as the steel was thought to have set, e. g., five minutes after pouring; the other was left in the sand for twenty-four hours. The one shaken out in five minutes was white hot, and I doubt if the metal in its riser had completely set; the other was warm enough to be slightly uncomfortable to hold in the hand when shaken out. The sand used was their regular green molding sand, moistened the same as for their regular work.

Sections were cut from the test blocks and photographed as cast. Other sections were annealed by putting in a small electric furnace and heated (with the furnace) to 1850° F., held at 1850° F. for one hour, air cooled, reheated (with the furnace) to 1580° F., held one hour and cooled in the furnace (Figs. 7, 8, 9, 10).

The physical tests, unfortunately, gave negative results, as blowholds were encountered, which of course would give poor results. I shall, therefore, have to say, as the College Professor said, that this part of the experiment failed, but the principle remained just the same.

However, the experiment did not entirely fail as the micrographs indicate. It will be noticed that a very marked difference exists between the test stripped hot and the test cooled slowly. From this alone, it is evident that a marked difference in the physical properties would result.

The sections cut from the test bars stripped hot showed dendrites, while the sections cut from the test bars cooled slowly do not, but instead show the well known ingot structure. The heat treated bars also show a marked difference; the bar stripped hot is still very dendritic while that cooled slowly in the sand has its cast structure well broken up and a fine grained steel resulted.

Temperatures as high as 1850° F. are rarely used in annealing steel castings in as much as high and low temperature double heat treatments are seldom employed.

In this experiment the dendrites were not broken up by the double heat treatment, therefore, it is not surprising that in commercial practice where only one anneal is used and the temperature employed is two hun-

dred or more degrees Fahrenheit lower, that dendrites are still to be found and are troublesome.

The conclusion to be drawn from this experiment, together with many poor physical tests from bars taken from castings known to have been stripped very hot and whose structures were very dendritic, is that dendritic steel can not commercially, at least, be broken up structurally, therefore, to strip a casting while very hot gives rise to dendritic steel, while if the casting is allowed to cool slowly the dendrites will be broken up, and a structure results that will respond to heat treatment satisfactorily. In other words, stripping hot is very bad practice, and is inviting rejection of the castings due to the inability to meet the test requirements.

Table 1

Physical Tests

Fig. 3	37000	75000	11	12	course crystalline fracture
Fig. 4	39300	63000	9	10	course crystalline fracture
Fig. 6	38600	72800	27	43.4	silky ½ cup fracture

Table 2

Experimental Data

Fig. 7 Stripped after five minutes. Unannealed.
Fig. 8 Stripped after twenty-four hours. Unannealed.
Fig. 9 Stripped after five minutes. Heat treated.
Fig. 10 Stripped after twenty,-four hours. Heat treated.
Heat treatment. 1850° F-1-A, 1580° F-1-F.

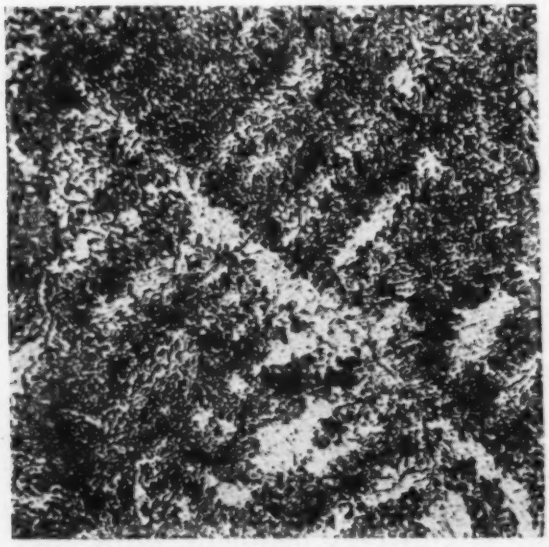

Fig. 3

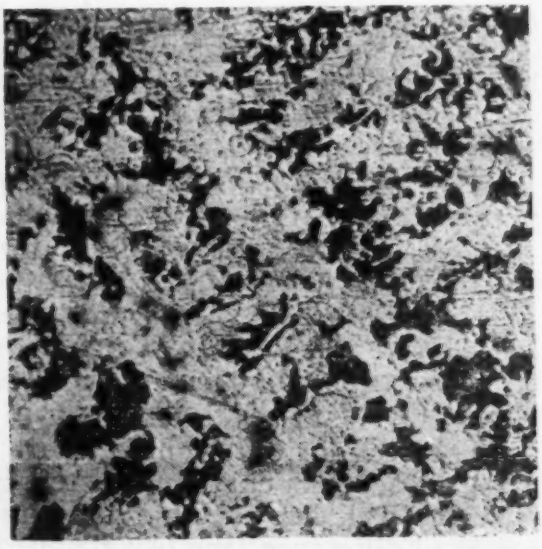

Fig. 4

Figs. 3 and 4. Dendrites found in small castings X100. Fig. 5. Unannealed structure from a large casting. Fig. 6. Annealed structure from a large casting. Figs. 5 and 6. X100.

Micrographs from experiment X100

Fig. 7. Test stripped in 5 min. unannealed. Fig. 8. Test cooled 24 hours, unannealed. Fig. 9. Test stripped in 5 min. heat treated. Fig. 10. Test cooled 24 hrs. heat treated. Heat treatment 1850° F-1-A, 1580° F-1-F.

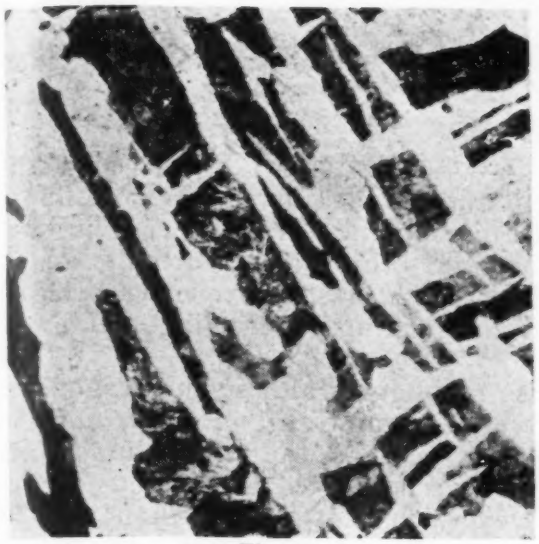

Fig. 5

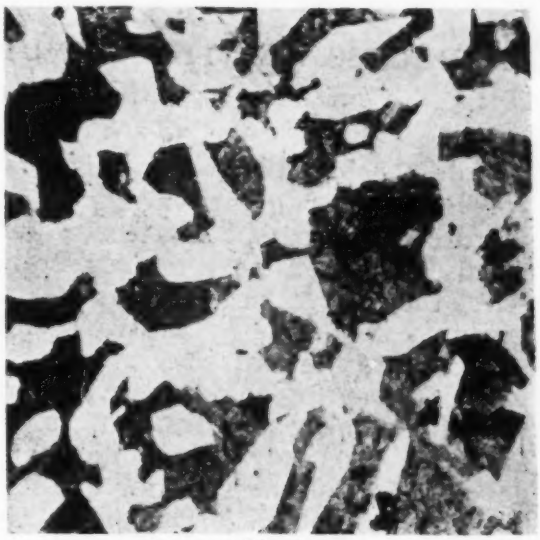

Fig. 6

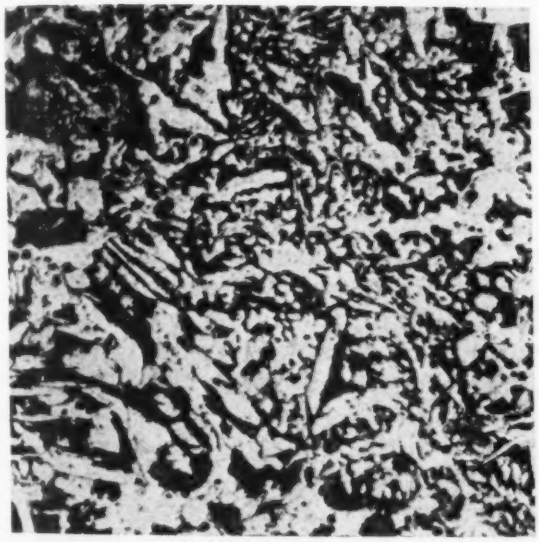

Fig. 7

Fig. 8

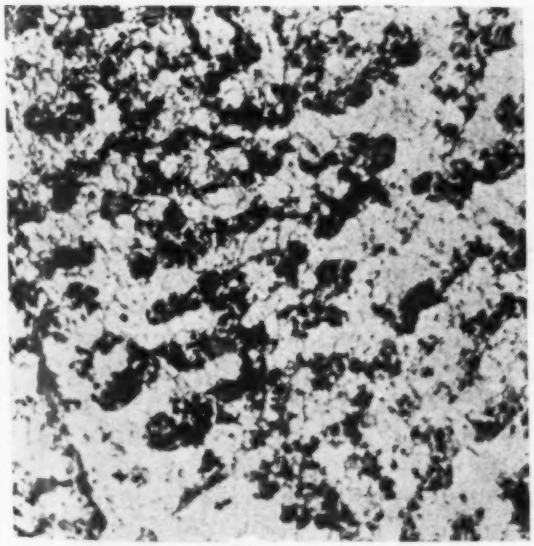

Fig. 9

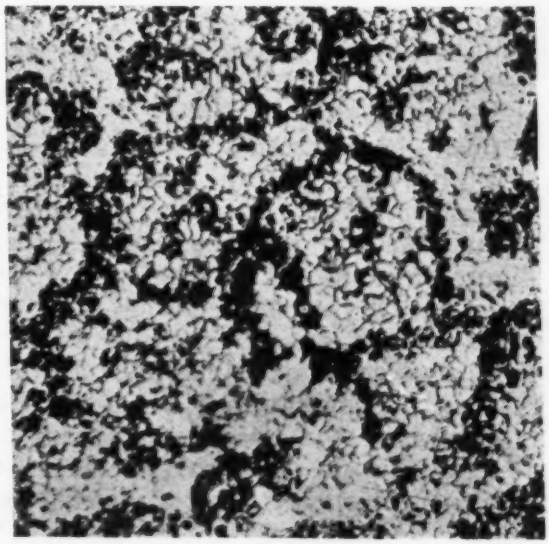

Fig. 10

A PROCESS FOR THE MANUFACTURE OF HELICAL SPRINGS FOR HEAVY DUTY

T. D. Lynch*

Read Before American Society for Steel Treating Convention, September, 1920

Springs of great variety of design and quality have been manufactured from flats, rods, ribbon and wire during the ages past. Some of them have been heat treated before forming, others after forming and still others have had no heat treatment, the high elastic properties being given to the latter by the work done in cold rolling or drawing the raw stock to its finished size.

Early spring making was for the use of buggies and spring wagons, then for clocks, watches, cars, locomotives, etc., and still later for automobiles. To the automobile manufacturer belongs the credit for the development of the superior quality of springs now used in the construction of automobiles. This progress, however, has not been without concentration of purpose relative to both material and treatment and each step has inscribed its mark of success or failure.

In this age of mechanical design, when every ounce of strength is exacted from each member, new problems arise continually in the use of springs demanding the highest quality possible to produce. To meet this growing demand for quality, every phase of spring manufacture must be coordinated and carefully processed at the furnace, at the rolling mill and at the spring making plant.

The steel maker has offered his carbon spring steel made in large open hearth furnaces, which has its field of application but is not strong enough for the most severe conditions that must be met at this time. Chrome vanadium steel, silico-manganese steel and chrome molybdenum steel have much higher elastic properties and are capable of withstanding proportionally greater stresses. Therefore, these and other alloy steels must be considered in connection with this high class work.

Within recent months one of the writer's duties has been to assist in the procurement of helical springs for a unique and unusually severe duty. The accompanying photograph shows the general problem involved, which consists in the transmission of the driving power of a motor to the wheels of a locomotive through a set of cushion springs. The arrangement is such as to permit free vertical and lateral wheel play. In this application the stresses are tension, compression, torsion and shear, separately or in combination, and these stresses are augmented from time to time by shock, producing a condition that makes necessary a material of high elastic strength, and, at the same time, a large degree of toughness.

The first step in the study of this problem was to investigate the general practice of spring makers—to find that the general process in vogue for the manufacture of springs from bars larger than 3/8 inch diameter is to obtain the bars from the steel maker, produced in large open hearth furnaces, rolled in a commercial manner, representing tonnage production. Bars thus made are heated to a temperature varying more or less from a bright to a dull red at different parts of their length, coiled into springs and quenched from this irregular coiling temperature. It is needless to say that springs made by such a process cannot be depended upon in severe service.

A few spring makers have realized the need for greater care in

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making and heat treating springs for heavy duty and a receptive attitude towards better spring making is now being taken by them.

Spring steel, and especially alloy spring steel, cannot be too carefully made, nor can it be too carefully coiled and treated in order to produce a strictly reliable finished product. Therefore, let us assume that the steel is carefully made and rolled into rods by the processes known to the steel makers as their best, coiled into springs at a proper and uniform temperature and finally treated by steel treaters represented at this meeting, under their best practice. I am sure you will vote with me in the affirmative that only such manufacture and treatment can be expected to give us the very best results. This hypothesis being granted, let us propose a process for your consideration, covering the manufacture of a silico-manganese steel spring made from 1 inch rounds, including the making and rolling of the steel and the coiling, treating, testing and inspection of the spring, in order that we may procure the reliable quality above indicated. There are many alloy spring steels on the market, any one of which would require similar care in their making and fabrication, but for this paper we have chosen a silico-manganese steel.

The question now arises how should a spring of the highest quality be processed, including the chemical composition, manufacture of the steel—rolling of the billets and bars—heating and coiling of the spring—the heat treating—inspection and general care required throughout the different steps in order to produce the most reliable product.

The following process has been worked out and is submitted for criticism and suggestions from others who may have similar problems to solve.

Chemical Analysis

The steel shall be what is known as silico-managanese steel of the following chemical analysis, both on ladle test and check test from finished rolled bars:

Carbon	.50—.60
Manganese	.60—.80
Phosphorus	not over .04
Sulphur	not over .04
Silicon	1.90—2.20

Manufacture of Steel

The steel shall be made by the crucible or electric furnace process and by a company that has been known to have produced high quality spring steel of the class specified.

The ingots shall be not less than 9″ square at large end and 8″ square at smaller end, so poured and the molds so coated as to give a smooth surface to the ingot.

Each ingot, when cold, shall be carefully inspected and any blemishes shall be chipped or ground out, leaving a surface that will be free from laps or seams after rolling.

Rolling of Rounds:

The ingots shall be slowly and carefully heated to approximately 1100 degrees Centigrade and rolled or forged to squares of approximately 3″ by 3″ and sheared into suitable billet lengths for final rolling. Excessive reduction will not be permitted.

Sufficient discard shall be made so that no signs of piping or segrega-

tion can be found when careful inspection is made, especially of the top cut.

The billets shall be allowed to become cold and a very careful inspection made for surface defects and any slight blemishes ground out, leaving a smooth, even surface, no ragged corners or slivers being permitted.

The billets shall then be heated to approximately 1100 degrees Centigrade and rolled to finish size, great care being taken to avoid excessive reduction at any one pass.

The bars shall be sheared to length and carefully inspected for piping, segregation and surface defects. Each bar shall be straight, free from surface cracks, scratches, seams, folds and indentations and shall be true to section. The diameter of the bar shall not vary more than two and one-half per cent from that specified.

Packing and Marking of Bars:

All bars shall be tied in bundles and a metal tag securely attached to each bundle. This tag shall have stamped on it the requisition number, heat number, size of rod and manufacturer's identification mark. When bundles are opened great care must be exercised so as not to nick or in any way injure the bars. A nick or scratch in a bar, however, small, can not be permitted.

Coiling of Springs

The bars shall be heated slowly to a uniform temperature of approximately 925 degrees C. (1700° F.) and immediately coiled over a mandrel preheated to at least 100 degrees C. The mandrel shall not be water cooled nor shall any water be allowed to touch the spring while hot.

Notching for length shall be done at a dull red heat and in such a manner as not to cut, scratch or otherwise injure the surface at any other point on the spring.

The springs after notching shall be allowed to cool slowly and uniformly in such a manner as to prevent local chilling which may cause surface stresses or cracks to form.

Treatment:

The springs shall be slowly and uniformly preheated to approximately 700° C. (1290° F.), transferred to a furnace held at a quenching temperature of 900° C. (1650° F.) and uniformly heated as near as possible to this temperature and quench in oil.

The quenched spring shall be drawn in a salt bath at approximately 455° C. (850° F.) to relieve quenching stresses.

The drawn springs shall be cleaned from the adhering salt by a hot soda wash, followed by an oil or lime dip to protect them from corrosion.

Physical Properties and Tests

The properties specified below shall be determined in the order given. The spring shall not be rapped or otherwise disturbed during the test.

(a) **Solid Height**—The solid height is the perpendicular distance between the plates of the testing machine when the spring is compressed solid with a test load of at least 125% of that necessary to bring all the coils in contact. The solid height shall not vary more than 1.5% from that specified.

(b) **Free Height**—The free height is the height of the spring when

the load specified in Paragraph (a) has been released, and is determined by placing a straight-edge across the top of the spring and measuring the perpendicular distance from the plate on which the spring stands to the straight edge, at the approximate center of the spring. The free height shall not vary more than 1.5% from that specified.

(c) **Loaded Height**—The loaded height is the distance between the plates of the testing machine when the specified working load is applied. The loaded height shall not vary more than 1.5% over nor more than .75% under that specified.

(d) **Permanent Set**—The permanent set is the difference, if any, between the free height and the height (measured at the same point and in a similar manner) after the spring has been compressed solid three times in rapid succession with the test load specified in Paragraph (a). The permanent set shall not exceed .4% of the free height.

(e) **Hardness Tests**—The Brinell hardness number shall not be less than 375 nor more than 450. This test shall be made on the coupon resulting from notching to length and broken off after spring has been heat treated.

(f) **Structure**—The grain structure of the finished spring should be troostitic or troosto-sorbitic.

Dimensions

The springs shall be straight, with uniform pitch, and shall remain straight throughout the working range.

The diameter of single coils of the spring shall confor mto the tolerance given on the drawing.

The concentricity of the coils of the spring shall be determined by means of a plug-gauge and ring-gauge, extending the full length of the spring and having the following dimensions:

	Length of Spring	
	10″ or less	Over 10″
Outside diameter of plug gauge....	d minus .063	d minus .094
Inside diameter of ring gauge.....	D plus .063	D plus .094

Where "d" is specified inside diameter of spring.
"D" is specified outside diameter of spring.

When the drawing specifies a spring with ends squared and the spring is placed with either end on a flat plate, its axis shall not make an angle of more than 5 degrees with a perpendicular to the plate.

Resetting of Spring

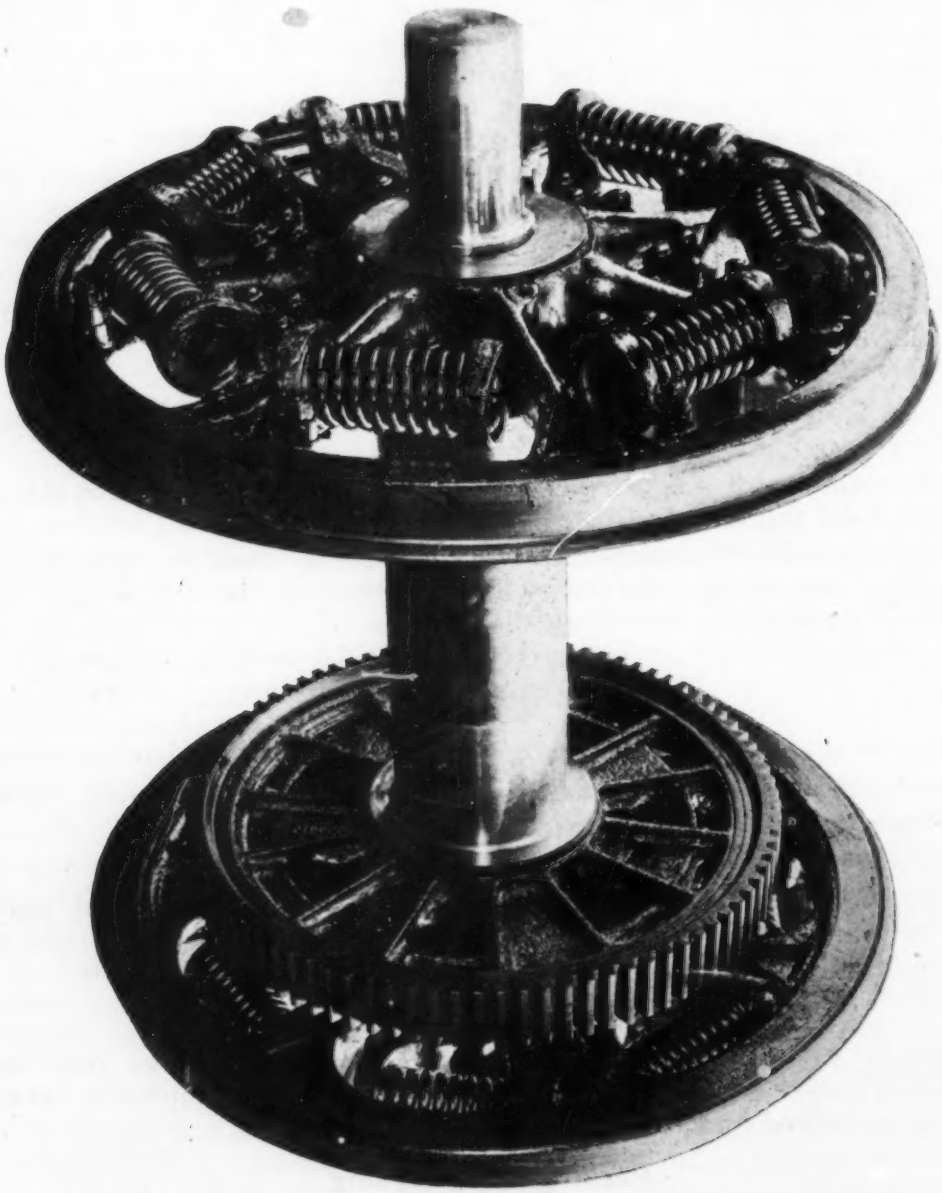
Springs varying from the required finished dimensions may be reheated and reset but all such reset springs shall be completely retreated —that is quenched and drawn again.

Packing and Marking

All springs shall be plainly marked with serial numbers and manufacturer's identification letter at one end of the finished spring and on each coupon resulting from notching to length. The purchaser shall assign the serial numbers to be used with each order.

Each size of spring shall be packed separately in such a manner as to protect the springs from injury during shipment.

Each package shall be plainly marked as follows:
Requisition number.
P. D. Spec. No.
Number of springs.
Style number of spring (or drawing and item number if there is no style number).
Name of manufacturer.
For example:—Req. C-5100; P. D. Spec. No. ; 6 springs; Style No. 591500; Blank Company.



Inspection

Tests and inspection shall be made by the purchaser at the place of manufacture prior to shipment.

The inspector representing the purchaser shall have free entry at all times while the contract of the purchaser is being performed, to all parts

of the manufacturer's works which concern the manufacture of the springs ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the springs are being furnished in accordance with this specification.

This paper has included more than the heat treatment of springs and is intended to emphasize the great importance of a better knowledge of complete spring manufacture and bring together on common terms the designing engineer, the steel maker and the spring maker.

A full discussion is desired, hoping that the combined experience of the members of this organization may bring out additional data that will assist in establishing a complete and efficient process for the manufacture of truly reliable springs for heavy duty. It is further hoped by the author to have shown the need of coordinating the talent and experience of the men at the steel mill, rolling mill and spring coiling plant as well as the heat treating and testing of the finished product.

STEEL FOR MACHINE PARTS

Stationary and Moving

Carbonized and Heat-Treated

Robert M. Taylor*

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There has not been much information published to indicate to machine tool builders what materials are generally used by the machine tool industries. In most cases a selection of material was made by conferring with the steel mill salesmen. This method may have its advantages, but it has resulted in the same material being called by many different names. When a buyer tried to buy a material from a different source it was a difficult task to juggle the trade names, analyses and physical specifications to get a comparison.

The automobile manufacturers met with the same difficulties, and early in their career they clearly saw the advisability of preparing uniform specifications and classifications for materials for their industry, and through the American Society of Automobile Engineers they developed the SAE specifications for steels.

These steels have been manufactured in large quantities, some steel mills make a specialty of them, and practically all steel mills manufacture them.

If the same or similar classification were adopted by other industries it would greatly simplify the difficulties of the buyers and steel manufacturers.

Right here it may be well to explain the SAE system of numbers.

The first figure indicates the class to which the steel belongs, thus 1 indicates a carbon steel, 2 nickel, 3 nickel chromium, 5 chromium, 6 chromium vanadian, 9 silico-manganese steels. In the case of the alloy steels the second figure generally indicates the approximate percentage of the predominant alloying element.

The last two or three figures indicate the average carbon content in "points" or hundredths of one percent, thus, 3120 indicates a nickel

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chromium steel with approximately 1 percent nickel (1.00% to 1.50%) and 20% carbon (15% to 25%). Also 1020 indicates no alloy, straight carbon approximately 20% carbon (15% to 25%).

After but little study it all appears very simple, easily remembered and to anyone using steels the number convey most of the information needed to understand the qualities or use of the steel.

The heat treatments have also been standardized and the letters designating the heat treatments used in this paper are the SAE standard.

When you speak of 6120 B to an automobile manufacturer he knows you mean a carbonized Chromium-Vanadium part.

I have prepared a chart arranged particularly for buyers, draughtsmen and shopmen of the machine tool industry, showing steels met with in machine tool plants.

The analyses are designated by SAE numbers, but they are screw stock, hub stock, machinery steel, spindle steel, tool steel, spring steel, etc., called by another name.

The analyses shown are typical SAE, but they correspond to the best grade of stock supplied to machine tool users under other names.

The physical properties given have been secured from the best information available, but are not the results of actual tests which I can substantiate. I give them to show comparative strengths rather than a basis for ordering material.

The first nine steels cover about all requirements of the ordinary machine shop. I give the others because of their growing use in extreme service.

The following explanation of applications of materials to major machine parts may be of some benefit to draughtsmen and shopmen.

Shafting: No. 1020 is usually used in cold rolled state. This same analysis is also frequently used in "Turned & Ground" state. The cold rolled has a disadvantage in some cases where long keyways are to be cut due to the fact that the keyway will relieve the surface tension and cause the shaft to buckle or become untrue.

No. 1045 can be used for shafting requiring greater strength. The same remark concerning finish of No. 1020 also applies to No. 1045.

Spindles: No. 1045 made by crucible process is most generally used. This material can be heat-treated to increase strength when desired. Treatments D, E or H being used.

No. 3135 made by open hearth process in such quantities as to insure uniformity has been very popular with concerns demanding a high grade alloy steel spindle. It has not been the practice to heat treat this material for ordinary spindles, but the material improves so much with heat treatment that it is advisable to heat treat in all cases, especially if there are any keyways or shoulders. Some concerns run the hardness up to 60 shore, and finish machine after heat treating, but in general practice 38 to 45 shore hardness is best because at greater hardness cutting is very difficult. Treatments D, E or H are used.

No. 6135 is used for spindles in extreme cases where vibration and alternate stresses are most severe. It should always be heat treated, either before, during or after machining. 38 to 45 shore hardness is the best hardness for spindle service. Treatments T or U are used.

Gears: For gears for low speed and light load material No. 1020 is used in soft state.

For gears for low speed and heavy load materials 1045 heat treatment H up to 65 shore hardness.

3135 heat treatment H up to 65 shore hardness.
6135 heat treatment T up to 65 shore hardness.

For gears for high speed and light load materials:

1020 treatment A or B up to 95 shore hardness.
3120 treatment G up to 95 shore hardness.
6120 treatment T up to 95 shore hardness.

For gears for high speed and heavy load materials:

3250 treatment M or Q 72 to 80 shore hardness.
6150 treatment U 72 to 80 shore hardness.
9260 treatment V 72 to 80 shore hardness.

Cams: Where no severe strains are imposed on light sections No. 1095 can be used, giving treatments F or X, shore hardness up to 90.

Where greater strength is required use No. 3250, treatment Q, shore hardness up to 85.

Where extreme hardness is required use:

5195 treatment Q up to 100 shore hardness.
6195 treatment U up to 100 shore hardness.
9260 treatment V up to 100 shore hardness.

Centers: No. 1095 is almost universally used heating head in lead pot and quenching in water. Treatment X, giving 90 to 100 shore hardness.

Lead Screws, etc.: No. 1135 X is a favorite for this use because of its free and smooth cutting properties.

Sometimes No. 1020 is used for such screws, but it is not advisable to do so except for extremely light duty. 1045 is better. Sulphur in this stock should not be below .03 or it will be difficult to get a smooth finish on the thread.

Thrust Washers: 1020 or 3120 carbonized treatment B are used for light service and 1095 treatment X, 3250 treatment Q, 5195 treatment R for heavy service.

Ball Races, Rollers & Pins: 5195 treatment R is a favorite for this service, 80 to 100 shore hardness.

Springs:

No. 1095 treatment F is generally used.
No. 6150 treatment U for severe service.
No. 9250 treatment V for severe service.
No. 9260 treatment V for severe service.

Keys: No. 1020 in cold rolled condition is frequently used, but is not recommended except where extremely low price is required.

No. 1045 is much preferred in a tempered condition because of its ability to resist distortion. When a key begins to rock the lower grade material will distort very quickly.

No. 3250 treatment M is used for sliding keys, etc., where a wear proof key with great strength is required.

Bolts, Nuts, Pins, Studs & Screws: No. 1114 is especially made to permit rapid screw machine production, with smooth finish, consideration of strength being secondary. This material can be carbonized by treatments A or B.

No. 1020 will give much greater strength both in soft and carbonized screws, carbonized by treatments A or B.

No. 1045 can be used for a tempered screw, treatment H.

Tool Post Screws, etc.: For screws of extreme strength No. 3120 or No. 3135 treatment H will give best results, hardness not above 65 shore.

HEAT TREATMENTS

Heat Treatment A

After forging or machining:

1. Carbonize between 1600° F. and 1750° F. (1650°-1750° F. desired).
2. Cool slowly or quench.
3. Reheat to 1450°-1500° F. and quench.

Heat Treatment B

After forging or machining:

1. Carbonize between 1600° F. and 1750° F. (1650°-1700° F. desired.)
2. Cool slowly in the carbonizing mixture.
3. Reheat to 1550° to 1625° F.
4. Quench.
5. Reheat to 1400°-1450° F.
6. Quench.
7. Draw in hot oil at 300° to 450° F. depending upon the degree of hardness desired.

Heat Treatment D

After forging or machining:

1. Heat to 1500°-1600° F.
2. Quench.
3. Reheat to 1450°-1500° F.
4. Quench.
5. Reheat to 600°-1200° F. and cool slowly.

Heat Treatment E

After forging or machining:

1. Heat to 1500°-1550° F.
2. Cool slowly.
3. Reheat to 1450°-1550° F.
4. Quench.
5. Reheat to 600°-1200° F. and cool slowly.

Heat Treatment F

After shaping or coiling:

1. Heat to 1425°-1475° F.
2. Quench in oil.
3. Reheat to 400°-900° F., in accordance with temper desired, and cool slowly.

Heat Treatment G

After forging or machining:

1. Carbonize between 1600° F. and 1750° F. (1650-1700° F. desired.)
2. Cool slowly in the carbonizing mixture.
3. Reheat to 1500°-1550° F.
4. Quench.
5. Reheat to 1300°-1400° F.
6. Quench.
7. Reheat to 250°-500° F. (in accordance with the necessities of the case, and cool slowly).

Heat Treatment H

After forging or machining:

1. Heat to 1500°-1600° F.
2. Quench.
3. Reheat to 600°-1200° F. and cool slowly.

Heat Treatment M

After forging or machining:
1. Heat to 1450°-1500° F.
2. Quench.
3. Reheat to 500°-1250° F. and cool slowly.

Heat Treatment P

After forging or machining:
1. Heat to 1450°-1500° F.
2. Quench.
3. Reheat to 1375°-1450° F.
4. Quench.
5. Reheat to 500°-1250° F. and cool slowly.

Heat Treatment Q

After forging:
1. Heat to 1475°-1525° F. (Hold at this temperature one-half hour, to insure thorough heating.)
2. Cool slowly.
3. Machine.
4. Reheat to 1375°-1425° F.
5. Quench.
6. Reheat to 250°-550° F. and cool slowly.

Heat Treatment R

After forging:
1. Heat to 1500°-1550° F.
2. Quench in oil.
3. Reheat to 1200°-1300° F. (Hold at this temperature three hours.)
4. Cool slowly.
5. Machine.
6. Reheat to 1350°-1450° F.
7. Quench in oil.
8. Reheat to 250°-500° F. and cool slowly.

Heat Treatment S

After forging or machining:
1. Carbonize at a temperature between 1600° F. and 1750° F. (1650°-1700° F. desired.)
2. Cool slowly in the carbonizing mixture.
3. Reheat to 1650°-1750° F.
4. Quench.
5. Reheat to 1475°-1550° F.
6. Quench.
7. Reheat to 250°-550° F. and cool slowly.

Heat Treatment T

After forging or machining:
1. Heat to 1650°-1750° F.
2. Quench.
3. Reheat to 500°-1300° F., and cool slowly.

Heat Treatment U

After forging:
1. Heat to 1525°-1600° F. (Hold for about one-half hour.)
2. Cool slowly.
3. Machine.
4. Reheat to 1650°-1700° F.
5. Quench.
6. Reheat to 350°-550° F. and cool slowly.

Heat Treatment V

After forging or machining:

1. Heat to 1650°-1750°.
2. Quench.
3. Reheat to 400°-1200° F. and cool slowly.

Heat Treatment X

1. Heat to 1425°-1475° F.
2. Quench in water.
3. Reheat to 300°-600° F. and cool slowly.

CONCERNING PYROMETERS

Editor's Note.—The following graphically illustrated article, dealing with the "lag" of pyrometers under certain conditions, was taken from the "Heat Treatment Bulletin," published by Automatic and Electric Furnaces, Ltd., London, England. We venture to say that there are few users of pyrometers who can not profit by its perusal.—Editor.

Some persons swear by their pyrometers, some swear at them, and a good many prefer to ignore them. Unless one understands them, the last is probably the wisest course to pursue.

The chief causes of error in pyrometery are the following:

The indicator changes its calibration due to weakening of the permanent magnet.

The couple changes its constants due to a change in the alloy of which the wires are composed. This change as a rule does not seriously affect the readings until the alloy has oxidized till only a very fine thread remains. The remedy is to use a couple of two pure metals, or, if this is not practicable, use one wire of pure metal and one of alloy, arranging their respective diameters so that the wire of pure metal parts first.

Probably the greatest errors are, however, due to sluggishness of the couple. A couple composed of two thick wires inside a tube of silica is bound to be sluggish, as all heat has to be passed through the tube and at the same time the thick wire is rapidly conducting it away.

Some tests have been made for sluggishness which are decidedly illuminating. Two couples were made up—one was composed of wires .195 in. diameter, the other of wires of .036 in. diameter. Both were tested bare and again protected by a silica tube, the same tube being used in both cases.

The procedure was to immerse a couple in the furnace, which was maintained constant at 900 degrees, and then to note at one-minute intervals the reading of the indicator as the couple heated up. The indicator employed was a mirror instrument with a scale 5 ft. long, on which readings could be taken to one degree with certainty.

The readings obtained have been plotted as curves in Fig. 1, the ordinates being degrees Centigrade and the abscissae minutes from the moment of immersion of the couple in the furnace.

It will be seen that the smaller wire unprotected reaches five degrees short of its final temperature in the first minute and attains its full temperature in three minutes.

The larger wire takes five and a half minutes to reach within five degrees of its steady temperature.

When the couples are placed in silica, the small wire is ten degrees

short at the end of 14 minutes and is five degrees short of its final temperature at 18 minutes.

The larger wire when protected by a silica tube takes 34 minutes to attain to within 20 degrees and 50 minutes to reach ten degrees of the furnace temperature.

It will be seen, therefore, that a couple made of wire .195 in. diameter placed inside a silica tube is not likely to be of any utility except in exceptional cases, as it will always be lagging behind the changes in furnace temperature by quite a serious amount.

The moral is that bare couples should be employed wherever permissible, but should a protecting tube be necessary, the wire selected should be as small as possible in diameter.

Having decided in favor of small wires, the next point to consider is the material of which the wires are to be composed. The requirements are cheapness, long life, and high thermo-E.M.F.

Platinum and rhodium are expensive and only give a comparatively small voltage. What, then, can be done with base metals? Let us first consider the question of life.

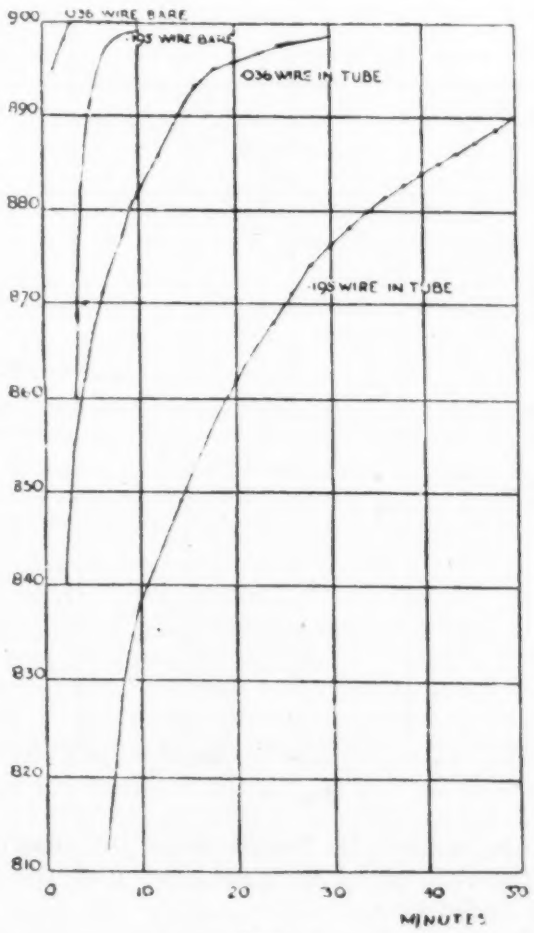

FIG. 1.

Five wires of the following materials, and all measuring about .035 in. diameter, were immersed in a furnace for two and a half hours standing at a temperature of approximately 1,000 degrees Centigrade. These wires were first gauged with a micrometer and afterwards were regauged,

the oxide having first been removed. The reduction of diameters found were as follows:

Eureka.....	.026	Nickel.....	.0015
Iron	.020	Nichrome.....	.001 or rather less.
Copper.....	.010		

These figures are not quite applicable to lower temperatures, as at 800 degrees Centigrade it is known that Eureka lasts rather longer than iron.

Clearly, a couple of Nichrome-Nickel is indicated as the best, provided that 1,000 degrees Centigrade is not to be exceeded, and provided, also, that this combination gives a good scale on the indicator.

In Fig. 2 is shown the calibration curves for five couples. The couples were tested in an oil bath against a thermometer, in freezing zinc, against the magnetic change point of iron, and against the melting point of copper.

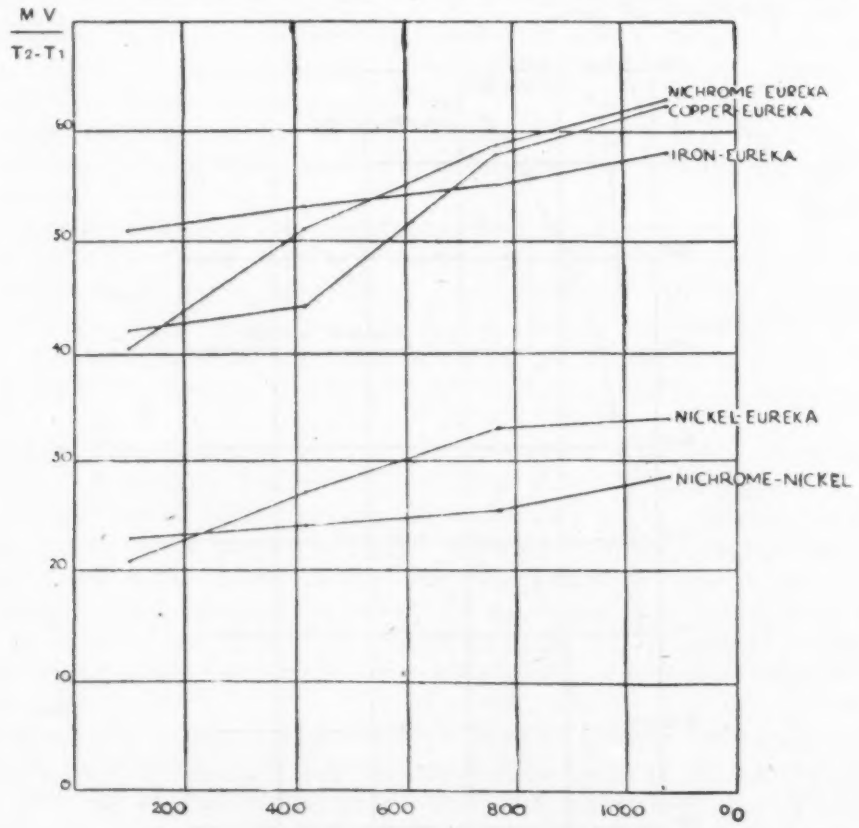

FIG 2.

The ordinates are scaled in micro-volts per degree of temperature difference between the hot and cold junctions and the abscissae are temperatures of the hot junctions.

Nichrome-Eureka gives the highest E.M.F. at the high temperatures. Iron-Eureka gives the most even scale. Copper-Eureka gives a very awkward scale, as there are two bends in it, necessitating testing at a greater number of points. Nichrome-Nickel unfortunately gives only about half the E.M.F. of Iron-Eureka. This would have, some years ago, necessitated the use of a suspended coil indicator, but of late years

instrument makers have so improved their pivoting that a pivotted coil instrument is now quite feasible.

In using alloys such as Nichrome or Eureka, it must be remembered that they cannot be relied upon to be always quite the same in composition. For example, two couples of Iron-Eureka, the Eureka being taken from different coils, have been found to differ in voltage by as much as ten per cent. Even on one coil it is quite usual to find differences of one per cent. Wherever a high degree of accuracy is required, it is necessary to test the couple with its own indicator throughout its working range.

For the majority of operations, however, it should be sufficient to supply each indicator and each couple with a batch number, it being understood that an indicator is only to be used with a couple bearing the same batch number as is marked on its scale.

RECENT PATENTS

1,340,913—May 25, 1920. METHOD OF AND MEANS FOR EXTENDING THE USABLE CONDITION OF METALLIC DIES AND TOOLS. Hellmuth Reinhardt Rosenbaum, of Brooklyn, New York. Specifications of Letters Patent. Application filed September 2, 1919. Serial No. 321,170. No drawing.

This invention relates to dies and tools made of steel and various steel alloys, and used for drop forgings, drawing, stamping, heading and otherwise shaping products of metal. These dies and tools are subjected to destructive wear by the shock, pressure, strain, etc., in the operation of the machines, in which they are used, and though made, as a rule, of the best quality of steel and steel alloys, the period of their usable condition is comparatively short. The object of my invention is to extend the period of their usable condition.

The efforts of producers of tool steels have been directed for many years to increase its toughness and otherwise improve its capacity to resist for a longer period the destructive effects, to which the dies for drop forgings, and tools for heading, drawing, etc., are exposed. My own researches and experiments were directed toward finding by what means, if any, the dies and tools made of the various steels, and steel alloys, may be maintained in usable condition for a longer period than heretofore. This led me to the discovery, that dies, punches and other similar tools for drop forging, heading and otherwise shaping of metallic parts, will, and do, withstand the destructive wear better, and for a much greater length of time, if they are artificially heated to, and kept heated while they are being used, at a temperature above their natural temperature and lower than that applied thereto in the hardening process. Roughly speaking this temperature at which the dies or tools are to be kept during their periods of active use varies from about 300 to about 1100° F., the degree of the temperature at which a die or tool is to be kept depending on the characteristics of the steel, or alloy, of which the die, tool, etc., is made. The tools or dies, made of some particularly compounded steels, and steel alloys, may have to be heated to, and kept at, a yet higher temperature than the maximum stated above, but the rule, that the temperature is to be somewhat lower than that to which the material (steel or alloy) of which the die, or tool is produced, must be heated in the hardening process, applies equally also to tools, or dies produced of these particularly compounded steels, or alloys.

To determine the temperature, which should, or may be, applied to a particular die or tool to attain the object of this invention, requires the

knowledge of the composition of the steel, or alloy, of which the die, or tool is made, or of the temperature to which it must be heated in hardening it. This information is readily obtainable from the maker of the steel or alloy, if not stated in the specifications, according to which the steel or alloy was produced. The examples here given are of steels and alloys generally known and now used for the enumerated and similar work.

Considering first the ordinary straight carbon tool steels, largely used for drop forging dies, *i.e.* steels, containing from 0.75 to 0.90% carbon, and which are heated to 1400-1475° F. for hardening and whose tempering heat does not exceed 750° F., a very high degree of toughness and resistant capacity is imparted to a die, or tool, produced of such a straight carbon steel, by heating it to, and keeping it while it is being used, at a temperature from about 400° to 600° F., the further rule being, in this instance, that the lighter the dropping weight of the machine, in which the die or tool is being used, or the lighter the stock and the easier the metal flows, of which the drop forging is to be produced, the nearer to the stated lower limit of the temperature the die may be heated and kept. I found also that it is preferable to heat and keep the tools or dies, made of straight carbon steels, at a lower temperature than tools or dies made of alloy steels, because the continuous application to the straight carbon tool steels of a temperature nearer to that to which they are heated in the hardening process will result in reducing their hardness.

Dies, or tools, made of steels alloyed with chrome nickel, carbon chromium, chrome vanadium, cobalt chromium, tungsten or molybdenum, will in some cases scarcely be affected by temperatures ranging up to 1100° F. This applies, for instance, to a tungsten high speed steel of approximately the following composition: C, 0.65; W. 16.00; Cr, 3.40; V, 0.80%. Tools, or dies, made of the so-called "tungsten high speed steel" of this or similar composition for heavy forging, trimming and blanking will stand a much longer service if heated to 1100° F., and kept at that temperature while they are being used. The period of their usable condition may be more than doubled thereby. Tools, or dies, made of cheaper grades of high speed steels, without any tungsten, for instance, a patented cobalt-chromium combination, containing about:—C, 1.50; Co, 3.25; Cr, 12.00; Mo, 0.75%, may be kept at a temperature of about 850° F. without losing the required degree of their hardness.

Dies for hydraulic bulldozing and compression work, as well as hot trimming and blanking, made of alloy steels containing approximately C, 0.45; W, 2.00; Cr, 1.00; Si, 0.80% if heated to about 500° F. and dies and tools for hot trimming, drop forging and hot or cold bolt heading, produced of steel containing about C, 0.90; Mn, 0.40; Cr, 3.50; Si, 0.20%, will have likewise their usable condition maintained for a much longer period if heated to about 750° F. and kept at that temperature while they are being used.

The heating of these tools and dies and maintaining them so heated while being used, may be effected in various ways. One method that I have found to serve well for all temperatures, and may be said to be perhaps the simplest and most inexpensive means, is to apply to the die, or tool, a jacket tightly packed with infusorial earth in a layer of suitable thickness, and then heating it by gas burners. In this way the die or tool will be heated uniformly, and then kept heated at, or very near, the requisite temperature, for many hours. Fine molding sand may be used instead of the infusorial earth. Or, any approved form of electrical heating apparatus may be employed.

Where it is more convenient, and the die or tool does not require to be heated above 600° F., an oil bath may take the place of the packing of infusorial earth; or a bath of molten lead or a combination of lead and tin may be used. In this connection it is well to note that a compound of 14 parts of lead with 8 parts of tin melts at about 420° F., and a combination of 38 parts of lead with 8 parts of tin at about 510° F., these temperatures being required more frequently, and the molten condition of these compounds serving to indicate the temperature of the die or tool.

The heating of the tool or die and the heat of the packing, or bath, are controlled by a suitable heat measuring instrument set in a recess in the die or tool, in the packing, or in the bath, and provision may be made for continuously indicating the temperature of the dies or tools by providing suitable temperature indicating instruments therefor.

I claim as my invention:

1. The method of extending the period of usable condition of a metallic die or tool, which consists in artificially heating the die or tool above the temperature naturally resulting from the use of the die or tool and below the temperature to which it was subjected in the hardening process, and keeping the die or tool at such temperature while it is being used.

2. The method of extending the period of usable condition of a metallic die or tool, which consists in artificially heating the die or tool to a temperature which will not impair its hardness but above the temperature naturally resulting from the use of the die or tool, and keeping the die or tool at such temperature while it is being used.

3. The combination with a metallic die, or tool, of means for heating it, and for keeping it so heated while the die, or tool, is being used.

The combination with a metallic die, or tool, of means for heating it and of a packing for keeping it heated while the die or tool is being used.

1,322,511—Nov. 25, 1919. STABLE-SURFACE ALLOY STEEL. Percy A. E. Armstrong, of Loudonville, New York. Specification of Letters Patent. Application filed May 24, 1919. Serial No. 299,636. No drawing.

This invention relates to an alloy steel containing iron, silicon, chromium and carbon, and of a highly stable character, that is to say, highly resistant to change or deterioration, such as produced in ordinary steel, for example, by staining, oxidizing, corroding and the like agents.

The base or principal portion of the alloy steel is iron, on which the material is largely dependent for strength and for cheapness.

One of the effects of chromium when alloyed with iron is, as has long been known, in the direction of making the material more stable, or resistant to deterioration, such as surface corrosion, but chromium, used substantially or entirely alone as an alloying material with iron, has several disadvantages. Chromium and iron do not alloy well together and a streaky and irregular effect is likely to be produced, articles made from the same melt often differing widely in their qualities. Iron-chromium alloys have a tendency toward red shortness with resulting cracks, blemishes and fissures, and scale badly when heated to temperatures required for hot mechanical work during commercial operations. The quantity of carbon which can be present in iron-chromium alloys without causing very substantial loss of surface stability or resistance to deterioration is quite limited. With my improved alloy steel, difficulties of this character are either absent or are reduced to the minimum.

Without being limited to any particular theory of the action of silicon in the alloy, I believe that the very excellent character of the material obtained by my invention may be accounted for by the formation of a silicid or silicids of iron, and of a silicid or silicids of chromium, which iron and chromium silicids are miscible with one another when molten. In any event, the silicon acts as a third alloy material which is highly beneficial in bringing about the formation of a substantially homogeneous alloy, free from troublesome streaks and irregularities, of high surface stability and readily workable. This beneficial action of silicon is not appreciable where it is present only in small proportions, say up to .30-.40%. To get such beneficial effects at least .50% of silicon must be present and more silicon is desirable. With the use of silicon as described herein, it becomes possible to have the ground mass of the material substantially solid solution. The more the ground mass is solid solution, the greater appears to be the stability of the alloy steel produced. With the silicon in the alloy steel, greater amounts of carbon can be used than would be available for production of stable surface material without a substantial proportion of silicon.

I believe that the action of carbon is one of fixing or, in other words, one of setting up a lag or retardation to change in the alloy steel during cooling, and further that the carbon enters into combination with the iron and chromium, which combinations, however, are modified by the action of the silicon present.

With my new alloy steel large numbers of small areas, of appearance similar to carbids in straight carbon steel, may be distinguished under the microscope and, while I have been unable to isolate same, I am inclined to consider them to be chromium carbids, though they may be mere concentrations of the ground mass fixed in their condition by carbon, or may be accounted for in yet other ways. They are not points of local attack, for on etching with aqua regia they are etched less than the ground mass, and no intensity of etching is discernible on the boundaries of these small areas. When present in the material either in the as cast or as rolled state, or subjected to prolonged heating and slow cooling, they do not adversely affect its surface stability.

Proportions given herein are by weight and it is to be noted that the atomic weight of silicon being only about half of that of chromium or iron, the percentages of this component, if stated by volume, would be about twice the figures given herein.

For production of stable surface material to be subjected to mechanical working, the silicon content may be from about .50% to 8%, and the chromium for about 3% to about 50%, and chromium and silicon, taken together from about 5% to about 58%. Mechanical workability becomes very slight as the extreme upper limits stated are approached, but with up to about 25-30% of chromium and about 5-6% of silicon the material can be hot forged reasonably well. The material just described may be cast, in fact, it usually is cast into ingots before being worked mechanically, and castings may be made therefrom if desired. For making castings, however, which are not to be mechanically worked, more silicon may be used up to about 30%, and chromium up to about 60%, or even higher.

The alloy steel having over about 5% and under about 13% silicon and chromium, taken together, is practically stainless and is resistant to corrosion and the like, when the ground mass is fixed solid solution by heat-treatment, but is more or less readily attacked by corroding and the like agents when not in such state. Heat-treatment is necessary with this

material in order to obtain solid solution ground mass. For production of such material the silicon may be from .5% to 7%, and chromium 3% to 10%, the proportions being distributed between the two so as to keep the totals between 5% and 13%. With such low proportions of silicon and chromium, taken together, the carbon should be kept low to get good results. Carbon as low as .05% may be used. Preferably the carbon should be kept under one-tenth of silicon and chromium, taken together. With an alloy steel containing silicon 2.5% and chromium 3%, for example, the carbon should preferably be under .55%, since, with such material, further increase of carbon, to say 1%, results in a considerable reduction of the desired surface stability in the alloy steel. Carbon .30%, for example, gives good results with these proportions of silicon and chromium, provided the ground mass is fixed solid solution by heat-treatment.

With chromium and silicon, taken together, over 13%, and chromium over 10%, the material is substantially solid solution in the ground mass and has high surface stability whether heat-treated or not. With such chromium and silicon, the carbon content may be increased, without substantially reducing the desirable qualities of the material, as, for example, with chromium about 10 to 20%, and silicon about 2% to 7%, it is sufficient, so long as a maximum of 3.5% carbon is not exceeded, to keep the carbon below one-sixth of silicon and chromium, taken together. For example, one very good alloy steel contains chromium 13.7%, silicon 3.2%, and carbon 2.56%. If more readily workable material is desired, low carbon down to about .05% may be used and in such case the silicon may be less, down to about .5%.

With chromium above about 20%, the presence of any considerable amount of carbon tends to make the material brittle and difficult to work, if the silicon is low. Such material is readily workable, however, if the silicon is more than twice the carbon, up to about 8% of silicon. For example, an alloy steel having chromium 22%, silicon 4.5%, and carbon 2.1% has high service stability and works well. As before, 3.5% carbon is about the maximum for mechanically workable material. Considerable relative reduction in carbon is permissible, if desired, as, for example, another good alloy steel contains chromium 31%, silicon 6.12%, and carbon .68%.

As already stated the alloy steel, when used for making castings not mechanically worked, may contain up to about 60% chromium, and up to about 30% silicon. The carbon in such cast material should preferably be less than one-half the silicon.

With the silicon-chromium content about 13% or over, the alloy is highly resistant to change or deterioration in the hot state. Cast into ingots it forges and rolls with very noticeable absence of mill scale, and when rolled down has practically nothing but a sort of brownish "rouge" on the surface, of extreme thinness. When exposed to an oxidizing atmosphere at about 1800° F. for over a month, a specimen containing about 12% chromium, 5% silicon and .45% carbon, showed no more than surface darkening. Alloy steel of this composition does not melt until heated to about 2600° F., and this specimen had a specific resistance of 115 microhms per cubic centimeter. Such material, and material having still higher silicon-chromium content is well adapted for electrical heating elements, particularly where run at high temperatures, which may be as great as 1800-2000° F. or even higher, the temperatures permissible depending to some extent, at least, upon the times they are maintained. For electrical heating elements where lower temperatures are sufficient, say 1300° F. or so, the material may have less silicon-chromium content, so long as silicon and chromium,

taken together, are over 5%. The specific resistance of an alloy steel of about this proportion is about 65 microhms. The specific resistance increases much more rapidly with increase of silicon than with increase of chromium. The cast material as well as the mechanically worked material may be made use of for electrical heating elements. When the production of electrical heating elements involves a drawing or bending operation the carbon should be kept low, for example, under 13% of chromium and silicon taken together, carbon may desirably be about .40% and for over 13% silicon-chromium content, carbon about 1% gives good results. Higher carbon may be used where heating elements are produced by casting or like operation or material cold bending is not involved.

In the production of my improved alloy steel, great practical advantage can be taken of the fact that silicon is present to a substantial extent in the alloy, along with chromium. The production of alloys containing chromium with little or no silicon requires ferro chromium of high purity, which is expensive to produce. I have found that silicon may be used as a good and inexpensive reducing agent in preparing the ferro-chromium for my alloy steel. Silicon, when used as a reducing agent, enters to a considerable extent into the molten metal as an alloy component, and in this way a ferro-chromium-silicon alloy may be cheaply and conveniently produced. The ferrous alloy so obtained, may be made use of directly in the melting furnace, with, of course, the addition of other materials for obtaining the proper proportions of the various alloy components, and various grades of ferro-chromium-silicon may be utilized by proper choice of other materials. In this way the process of manufacture is simplified and a considerable saving effected of valuable materials, including chromium and silicon. From 80% to nearly 100% of the silicon and practically all the chromium used in the melt can be gotten in the finished product, particularly when the melting is done in the electric furnace, which I consider the desirable apparatus for the purpose, though other systems of melting may be used, if desired, and materials from other sources may, of course, be used.

The known silicids, especially the chromium silicids, can be used to advantage as a ready guide to the production of good quality alloy steel and the nearer the composition is to that of the known silicids the better appears to be its surface stability.

My new material has quite distinctive cooling and heating curves, showing two marked transformation points or stages, the upper one of which tends to rise with increase of silicon and chromium content, or with increase of silicon content alone.

The material has a long plastic stage when melted and cast into an ingot or other mold; with small molds it readily solidifies into coherent ingots which can be worked to good advantage. When cast into larger molds the period of silidification is quite long unless provision is made for withdrawing the heat very rapidly. When means are not resorted to to keep down the time for solidification, the casting may be done by top pouring of the metal from the ladle with a considerable proportion of slag which forms a protecting envelope all around and over the molten metal, and can be readily knocked off when the ingot has been removed from the mold. Pouring rapidly as, for example, through a large nozzle, has been found to be of advantage in casting operations.

As an instance of the abnormal plastic stage or undercooling of my alloy, one batch of 5 tons containing about 17% chromium, about 4.5%

silicon and about .80% carbon which did not melt until it reached a temperature of about 2600° F., remained molten for considerably over an hour, and was still molten even when the temperature had fallen to below 2000° F. This long plastic stage has the valuable property of eliminating pipe in properly cast ingots or other castings to a very large degree and it is useful, particularly in making small castings, for readily producing castings of great soundness. The plastic stage is likewise quite long upon heating. This long plastic stage can be utilized to good advantage in making various articles and shapes from my new alloy steel, as, for example, it may be extruded or press or drop formed into pipes, bars and shapes of various kinds.

An important property of my new alloy steel is its high resistance to rapid heating or cooling. Placed in a furnace with a piece of ordinary carbon steel, for example, of like dimensions, it remains black for some time after the ordinary steel has been heated to a yellow heat. When made use of for gun linings and the like, where the surface is subjected to the action of nitrous vapors at extremely high temperatures for short periods, highly destructive of materials which heat and cool rapidly, this material gives extremely good results and is highly resistant to erosion. By reason of this same characteristic it is well adapted for a variety of important uses, such as annealing tubes, boxes and articles which are subjected to varying temperatures over long periods. This valuable property of slow heating enables the charge in the annealing boxes and the like to be more uniformly heated than is possible with the alloys or metals at present employed for such purposes.

My improved alloy has the important property of not being readily permeable to gases at high temperatures and is, therefore, well adapted for apparatus such as containers for highly heated gases being subjected to chemical reaction, and for use in tubes for protecting thermo couples of pyrometers, and the like, where it is important to shield highly heated metallic material from being corroded by attacking gases.

The new alloy material, especially when it contains above 13% silicon and chromium taken together, is not attacked or stained to any perceptible extent by nitric acid, nor by acetic or other organic acids, fruit juices and the like. It is attacked to some extent, however, by hydrochloric acid, sulfuric acid, and hydrofluoric acid, particularly when diluted.

My improved alloy steel, containing substantial proportions of silicon, has greater surface stability, that is to say, is much more resistant to stain, oxidation, corrosion and the like, than similar materials not containing a substantial proportion of silicon. Ingots and billets made from my alloy are worked with practically no formation of mill scale whatever, whereas material of analysis similar to my alloy steel, but containing no silicon more than a very small percentage, for instance, 3%, when heated for hot mechanical working, will scale very badly. So extremely resistant is my alloy steel to oxidation that when carbon analysis is being run, by passing oxygen thereover in presence of high heat, it has been found impossible to get the carbon out by combustion without the addition of oxid, such as lead oxid, so as to set up a chemical action upon the carbon, whereas with an alloy containing the same amount of chromium as my material, but with little or no silicon, an accurate determination of carbon by oxygen can be readily made without resort to use of foreign oxids or the like.

The alloy steel of my invention, within the ranges given for mechanical working above, can be readily worked and is not red short, and is

remarkably free from troublesome cracks, fissures, blemishes, and the like. As an instance of its remarkable freedom from surface seams, a 7 inch ingot heated to the necessary temperature for rolling, was cogged down in an 18 inch mill in the billet form, then reheated and rolled in a 9 inch bar mill down to a ½ inch round bar, and was entirely free from cracks, and seams of any sort. A 12 inch square ingot, cast with an envelop of slag, and containing chromium about 17%, silicon about 4.5% and carbon about .8% was forged under a steam hammer, cut into billets and rolled down to a 5/16 inch square bar, with similarly good results. Such goods results are very difficult to obtain, even from low carbon steel free from alloys, and impossible to obtain from stel containing any such percentage of chromium, with no more than .30% of silicon and with such higher carbon.

Some of the uses of my improved alloy material have already been referred to, including electrical heating units, castings, cutlery and tools, gun linings, annealing tubes, etc. My alloy steel is eminently suitable for a variety of other uses, including flat iron bases, laundry machinery, propellers, water pipes and pumps for fresh and salt water, for refrigerator pipes and fittings, and generally for apparatus, fittings, etc., which are exposed to heat, moisture, steam or intense cold; for apparatus and articles exposed to action of alkalis to which the alloy steel is highly resistant, also for objects exposed to the atmosphere, such as hinges, latches, and outside hardware generally, for electrical fittings, for power transmission, electric trolley or railroad service, particularly those parts that have to withstand electrolysis, balls for water valves, ball bearing balls and races for ball bearings which have to work under water, ship fittings, surgical instruments, dental tools, steel rules, articles for personal wear, such as jewelry settings, coins and medals, automatic stoker bars which have to withstand high temperatures, and very many other purposes where high resistance to stain, oxidation and corrosion are required. The alloy steel has low magnetic hysteresis and by suitable heat-treatment can be made substantially non magnetic. These qualities make it available for many additional uses, such as in scientific instruments, electrical meters and the like.

My improved alloy steel, of course, contains small percentages of metalloids, such as sulfur, prosphorous, arsenic, etc., and may contain variable percentages of metallic elements, substantially all of which can be employed, to some extent, at least. If the chromium-silicon content is high the quantity of metallic elements which may be present without substantial detriment to the surface stability of the alloy steel may be correspondingly increased. It is undesirable, ordinarily, to include any of these metallic elements in percentages over 1%, when the total chromium and silicon used is as low as 5%, but when 13% or more of chromium and silicon is used, other metallic elements can be incorporated up to a total of about 2% to 5% without substantial detriment to the valuable properties of my alloy steel. I may, for example, incorporate with the alloy steel having chromium-silicon content of 13% or over, as much as 4% of cobalt, or nickel, 1% of manganese, molybdenum, tungsten vanadium, titanium, zirconium, or other metals which form silicids or compounds or alloys with the iron, or chromium or both, or which do not materially effect the solid solution ground mass, with no considerable detriment resulting from their use.

1. An alloy steel of high surface stability containing chromium 3% to 50%, carbon .05% to 3.5% but not more than 1/10 of chromium and silicon taken together up to about 13% thereof and not more than 1/6 thereof above about 13%, silicon under 8%, over .5% and also over twice

the carbon, silicon and chromium together 5% to 58%, and the principal portion of the remainder iron.

2. An alloy steel of high surface stability containing chromium over 10%, carbon over .05% silicon over .5% chromium and silicon together over 13%, and the principal portion of the remainder iron.

3. An alloy steel of high surface stability containing chromium over 10%, carbon over .05%, silicon over .5% and also over twice the carbon, chromium and silicon together over 13%, and the principal portion of the remainder iron.

4. An alloy steel of high surface stability, containing chromium 10% to 20%, silicon .5% to 8%, chromium and silicon together 13% to 28%, carbon over .05%, under 3.5%, and also under 1/6 of chromium and silicon taken together, and the principal portion of the remainder iron.

5. An alloy steel of high surface stability, containing chromium over 10%, carbon over .05%, and more than twice as much silicon as carbon, and the principal portion of the remainder iron.

6. An alloy steel of high surface stability, containing chromium 3% to 50%, carbon .05% to 3.5%, silicon .5% to 8% and over twice the carbon, and the principal portion of the remainder iron.

7. A cast article of high surface stability composed of an alloy steel containing chromium 3% to 60%, carbon over .05% silicon .5% to 30% and more than twice the carbon, and the principal portion of the remainder iron.

MEMBERS, DID YOU RECEIVE YOUR COPY OF PROCEEDINGS, VOL. 2, NO. 13, ISSUED SEPT. 4, 1920?

"Inasmuch as there was an auto accident in transporting Vol. 2, No. 13, of the Proceedings of the past Steel Treating Research Society from the printers to the postoffice, about 200 copies of the Proceedings were destroyed. It is therefore impossible to determine which of our members did not receive this very interesting number, containing the papers of the "Symposium of Electric Heat-treating." If those members of the Society who did not receive their copy will mail a postal giving their name and correct present address to the Secretary's office, 208 N. Wabash Ave., Chicago, Ill., a copy of this issue will be cheerfully forwarded at once.

COMMERCIAL ITEMS

The Driver-Harris Co., Harrison, New Jersey, has issued 112 page booklet on the subject of Case Carbonizing. This booklet is well worth while and may be secured by addressing the company as above. The Introduction and table of contents are as follows:

INTRODUCTION TO CASE CARBONIZING

The rapid growth of the steel industry in the past thirty years has been reflected along all lines of metallurgical work.

The progress has been stimulated at every step by the scientific investigation of the problems involved. This scientific control has resulted in introducing economies in the operation of the older processes and in devising new methods for the attainment of new ends.

It is not surprising, then, to find that, in the field of "Case Carbonizing" or "Case Hardening," a large amount of information has been accumulated which is of value to the heat treater. It is no longer necessary to carry out the process of "Case Hardening" along purely empirical lines. The chemical reactions which are involved in the various methods used for "Case Hardening" are now well understood. The quality of the steel which should be used, the nature of the carbonizing compound, the temperature and time of the operation and the nature of the container have all been subject to investigation.

While this information is to be found in the scientific files, it frequently happens that it is not available to the heat treaters on whom devolves the practical application of the heat treating processes involved.

This booklet, then, aims to lay before the heat treater, in language which can be readily understood, the information which has been rendered available by the more recent scientific investigations.

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